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INSTRUMENTS

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Vol. 2. No. 4 Pittsburgh, Pa. April, 1929

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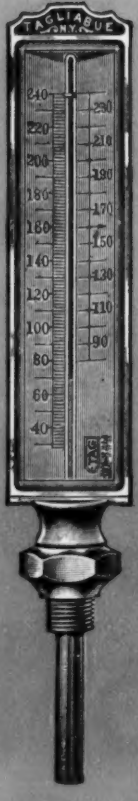

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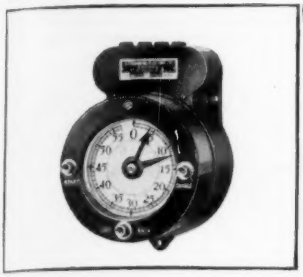

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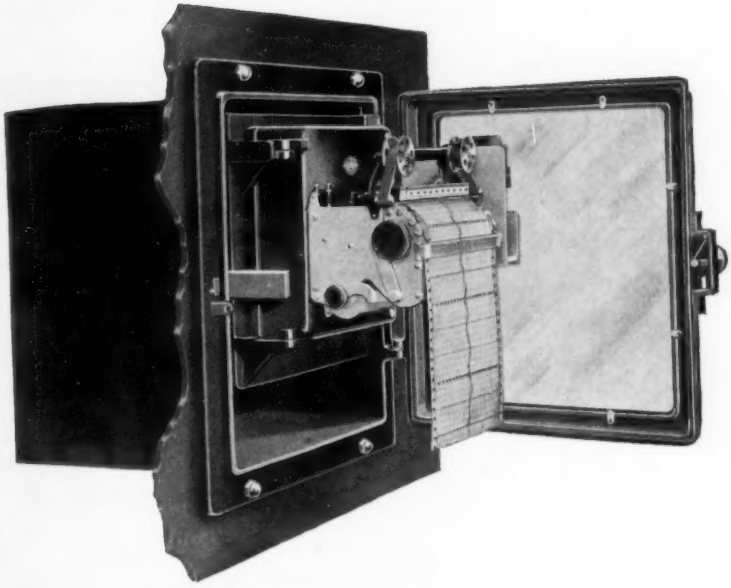

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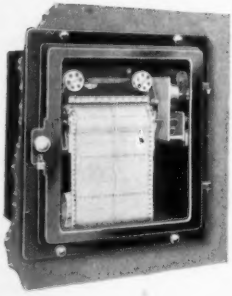

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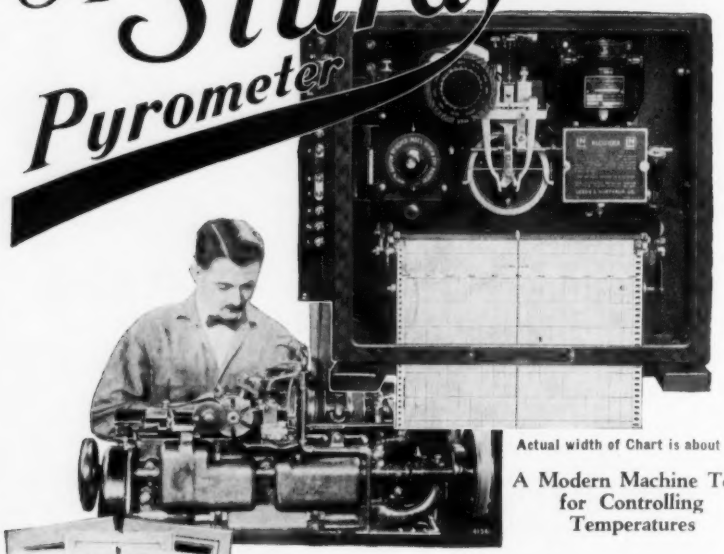

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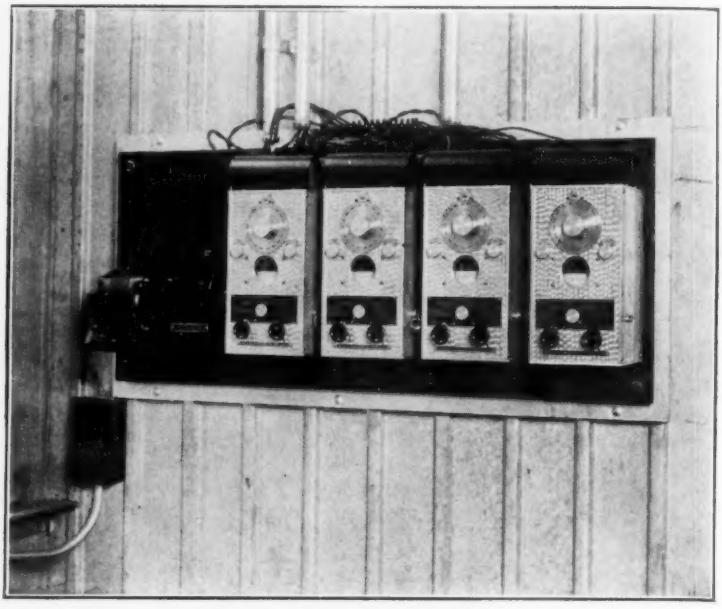
Have your stenographer cut out and mount the index found bound in the back of this issue, listing the principal articles. They will direct you to valuable information to which you may wish to refer in the future.



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Vol. 2, No. 4 APRIL, 1929 Pittsburgh, Pa.

To The Readers

THE Power Code Committee of the American Society of Mechanical Engineers have under consideration the adoption of an adequate terminology covering indicating and recording thermometers, that depend for their operation upon the expansion of liquids, the vapor tension of volatile liquids, and the expansion of gas. The old terms "Pressure Gauge" and "Bourdon Tube" thermometers are misleading.

The Chairman of the Industrial Instrument Section of the Association of Scientific Apparatus Makers of America is cooperating with the Power Code Committee. He approached the editor for suggestions. As this question will be of interest to the readers of INSTRUMENTS the editor would like an expression of opinion from all readers. A form is printed on page 13. Kindly send us your comments.

The Bristol Company and the Foxboro Company have for some time designated these instruments as Class I, Class II and Class III, in the same order as mentioned above. The editor offers the following terminology as being more desirable:

Liquid Pressure Spring Thermometers
Vapor Pressure Spring Thermometers
Gas Pressure Spring Thermometers

as there can then be no confusion as to which type is meant. It would greatly simplify matters, if all makers and users of instruments would adopt the same designation, regardless of which this might be.

Let us have an expression from YOU.

——— :: ———

For Those Who Can or Cannot Attend the Chemical Exposition

THE editor urges all the readers to attend the Twelfth Exposition of Chemical Industries the week of May 6th. Over forty industries furnishing material, and equipment, will display their products. Over 400 exhibits will occupy three floors of the Grand Central Palace, New York.

The editor will be glad to meet all those who attend the Exposition. Come to Booth No. 415 for a chat. MAKE OUR BOOTH YOUR HEADQUARTERS.

For those readers who cannot attend the Exposition, the Information Section offers a special service. The Information Section will obtain for you information, literature or prices on any instruments and devices for measurement, inspection and control which are exhibited. Write the Information Section and advise the types of instruments and devices on which you would like detailed information. For your convenience you will find a form on page 13, fill this out and return immediately. This service is entirely without charge.

———— :: ————

Editor's Note

IN using instruments of all makes to illustrate Mr. W. J. Healey's article PORTABLE ELECTRICAL INSTRUMENTS in the March issue, it may have created a wrong impression. Mr. Healey, being an Instrument Specialist for the Westinghouse Electric & Manufacturing Company, wishes it clearly understood that Westinghouse makes instruments in all classes described. The illustrations for this article were selected and sent in by the author, but substitutions were made by the editor.

———— :: ————

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The Measurement of Pulsating Currents**

*W. Nelson Goodwin, Jr.**

Before the principles of the measurement of pulsating currents can be fully understood it is necessary to know the meaning of the terms, "alternating current," "pulsating current," and "direct current," and the characteristics of each form of current.

A true alternating current is one which varies periodically, and in which the quantity of electricity transferred in one direction exactly equals that transferred in the opposite direction. That is, one in which the arithmetical average value of the current in one direction equals that in the opposite direction.

A pulsating current is also one which varies periodically, but the quantity of electricity transferred in one direction is greater than that transferred in the opposite direction; that is, the average value of the current in one direction is greater than that in the opposite direction.

A direct current is a current in one direction only, which does not vary periodically, and is usually considered constant during the time of measurement.

By varying periodically is meant that the changes in current occur in cycles having the same duration in time, all cyclic variations being exactly alike.

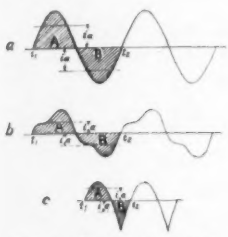

Fig. 1. Typical alternating current wave forms.

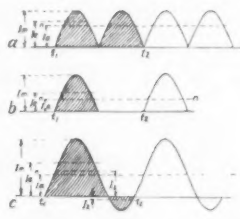

Fig. 2. Typical pulsating current wave forms.

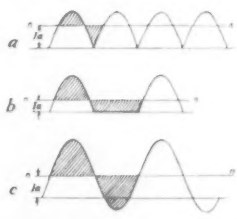

Fig. 3. Pulsating current considered as a direct current with an a.-c. component.

The curves a, b and c, Fig. 1, represent true alternating current wave forms, the ordinates of which correspond to instantaneous current values varying through complete cycles, one of which is shown from t_1 to t_2.

The area A above the zero line exactly equals the area B below the line, since these areas are directly proportional to the quantity of electricity transferred, and consequently to the simple average value Ia of the current in each direction.

Curve a is a pure sine wave. The wave may have any periodically varying shape, however, as for example that shown in curve b. Furthermore, an alternating current may have a wave form such as shown in curve c, in which the shape above the zero line differs from that below. To be designated as an alternating current it is only necessary that the wave form of the current shall vary periodically and have equal areas above and below the zero line.

The current in the ordinary commercial a.-c. circuits is true alternating current.

Pulsating currents, already defined, are usually produced by rectifying alternating currents, but can of course be produced by periodically varying a direct current, or by superposing an alternating current upon a direct current.

Curves a, b and c in Fig. 2 illustrate a few forms of pulsating current waves, in which one complete cycle is shown from t_1 to t_2.

Curve a illustrates the pulsating current resulting when both halves of an alternating current wave are rectified. The average value of the current is shown as Ia. Curve b shows a pulsating current where only one-half of the a.-c. wave is rectified, and the average value Ia is of course only one-half of the average value Ia in the curve a. Curve c illustrates a pulsating current where some reverse current is present, as would result from an imperfectly rectified alternating current. In this case the average value of the current Ia is the difference between the average currents in opposite directions I_1 and I_2.

A pulsating current may also be considered as a direct current on which is superposed a true alternating current. For example, if the curves in Fig. 2 are re-drawn as shown in Fig. 3, the average values Ia may be considered as unvarying direct currents, and superposed upon these are the a.-c. waves varying periodically above and below the value of the average current Ia. The a.-c. waves shown shaded are not in general sinusoidal but are nevertheless true a.-c. waves since the areas above and below the median line nn are equal.

Having clearly in mind just what pulsating currents are, we are now ready to consider methods of measuring them. It should be said before proceeding further that there is no general method for making this

*Chief Electrical Engineer, Western Electrical Instrument Corp.

**This article has been modified from one appearing in the Transactions of the Society of Motion Picture Engineers.

measurement. The method and instruments necessary to employe in any particular case depend upon the purpose for which the current is to be used, as will be made clear as we proceed.

The fundamental definition of current strength is based upon the electromagnetic force exerted upon a conductor carrying the current by a unit magnetic field under specified conditions. It follows from this that it is only to a direct current or to the instantaneous value of a

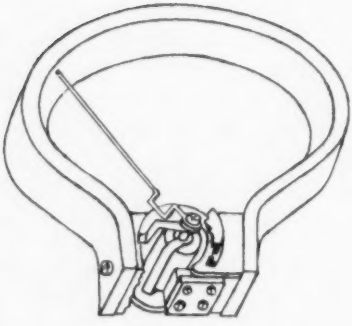

Fig. 4

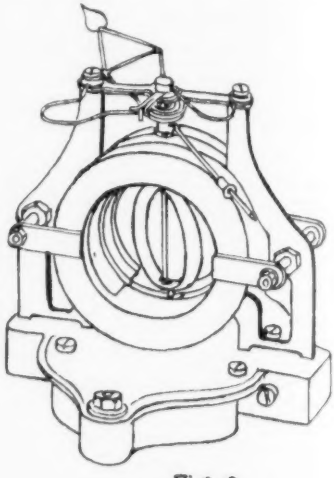

Fig. 6

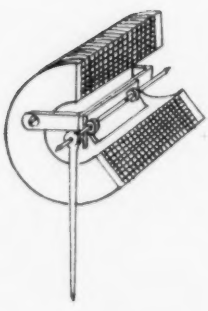

Fig. 5

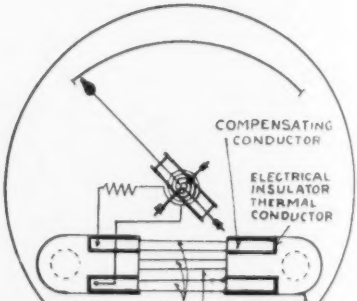

Fig. 7

Fig. 4. Mechanism of permanent magnet movable coil type instrument. Fig. 5. Mechanism of movable iron type instrument. Fig. 6. Electrodynamometer ammeter. Fig. 7. Thermal type instrument.

varying current that a value in amperes or other units can be assigned, which will be the same under all conditions. It is, therefore, only the instantaneous values of a pulsating current which can be said to have definite values and the same magnitude under all conditions. The value

assigned to the pulsating current as a whole is a conventional one depending upon the effect which the current produces in the circuit or devices through which it passes, and it may be defined as equal to the value of a direct current which would produce the same effect under the same conditions.

For example, as will be seen later, some effects vary as the square of the current and others as the first power, and therefore, the values to be assigned to any pulsating current vary correspondingly, and require different kinds of instruments for measuring them.

There are three general classes of instruments which can be used for the measurement of pulsating current, subdivided for purposes of this discussion according to whether their indications are proportional to the first or second power of the current or otherwise, namely:

(1) The permanent magnet movable coil type.
(2) (a) The movable iron type.
(b) The electrodynamometer type.
(c) The thermal type.
(3) The polarized vane type.

Permanent Magnet Movable Coil Type. This type has a coil, through which the current to be measured, or a known fraction of it, passes. The coil is pivoted and capable of rotating in the magnetic field produced by a permanent magnet, as shown in Fig. 4.

The forces tending to cause deflection in this instrument are proportional to the strength of the magnetic field and to the current. Since the field strength is constant, the indications are directly proportional to the current, that is, the first power of the current. Furthermore, since the field is constant, readable indications will result only for currents in one direction.

If, therefore, a pulsating current is passed through this type of instrument, the force tending to deflect the movable system at any instant is directly proportional to the first power of the current at that instant. If the frequency of pulsation is sufficiently rapid, as in the case at ordinary frequencies, the pointer does not follow the cyclic changes in current, but rests at a position which is the result of the average of the electric forces throughout the cycle. The instrument, therefore, measures the simple arithmetical average value of the pulsating current, that is, the values I_a shown in the curves in Fig. 2.

If the current follows a pure sine wave as shown in curves *a* and *b* in Fig. 2, then for the completely rectified wave, as curve *a*, the average value I_a indicated by the permanent magnet instrument will be $2\ I_m/\pi = 0.636\ I_m$, where I_m is the maximum or peak value of the wave.

For half-wave rectification as in curve *b*, the value I_a indicated is $I_m/\pi = 0.318\ I_m$.

For any other wave shape, as for example *c*, the relation between the peak and average values varies with the shape of the wave.

A permanent magnet movable coil type instrument, therefore, should be employed for measuring pulsating current only where the effect

throughout each cycle depends upon the first power of the current.

Specific applications of this principle will be referred to later.

Movable Iron Type. Fig. 5 shows a diagram of the mechanism of a movable iron type instrument.

Two pieces of iron are mounted as shown in the magnetic field produced by a coil through which the current to be measured passes. One piece is fixed and the other attached to the pointer staff and is movable. Both pieces of iron are magnetized together by the same field, and when so magnetized, repel each other, causing the pointer to deflect. The repelling force is proportional to the product of the magnetic effects in the two pieces of iron. Since each magnetic effect in turn is proportional to the strength of current in the coil, the resulting repelling force acting to deflect the pointer is proportional to the square of the current.

Electrodynamometer Type. In a similar manner it can be shown that in electrodynamometer instruments the deflecting forces are proportional to the square of the current through them.

A diagram of a typical form of this type of ammeter is illustrated in Fig. 6.

In this type of instrument a movable coil is pivoted, free to turn, within a fixed coil. The fixed coil usually carries the entire current to be measured, and the movable, all of this current, or a definite fraction of it. The deflecting forces are proportional to the product of the currents in the two coils. Therefore, the forces acting to deflect the pointer are proportional to the square of the current.

Thermal Type. This type, illustrated diagrammatically in Fig. 7, consists essentially of a metallic strip or wire through which the current passes, heating it to a temperature which is proportional to the square of the current passing through it. A thermocouple has its hot junction in contact with this heating strip and its cold junction connected through proper compensating conductors to a permanent-magnet, movable-coil type instrument. The indications of this instrument actually correspond to the temperature of the strip, but it is calibrated in terms of the value of the current passing through the heating strip. Since the temperature is proportional to the square of the current, the instrument indications are proportional to the square of the current, the same as the movable iron and electrodynamometer types.

When any of the three types just described is used to measure pulsating or alternating currents, its pointer cannot follow every cycle change in current, but will assume a position resulting from the average of the instantaneous forces acting throughout a cycle, and since these forces are proportional to the squares of the currents, the deflection will correspond to the average of the squares of the instantaneous values. The scales are ordinarily calibrated and figured in terms of the first power of the current so that it follows that the indication will be the square root of the average of the squares of the instantaneous values of the periodically

varying current. This value is known as the "effective value," and also the root mean square value usually designated as R.M.S.

To illustrate the various values of current so far discussed, let us consider them in connection with pure sine waves.

Referring again to Fig. 2, curve *a* shows a completely rectified sinusoidal wave, and curve *b*, one of half-wave rectification.

The average value I_a of the ordinates of the curves is the simple average value already discussed. The effective or R.M.S. value I_e is the square root of the average of the squares of the ordinates of the wave.

*For the completely rectified sinusoidal wave, as stated before, the average value $I_a = 2I_m/\pi = 0.636I_m$, and the effective or R.M.S. value is $I_e = I_m/\sqrt{2} = 0.707I_m$. That is, the effective value is 1.111 times the average value.

A movable iron, electrodynamometer or thermal type instrument will, therefore, indicate a higher value than the permanent magnet type by about 11.1 per cent for the same current, where the wave is sinusoidal and completely rectified.

*For the half-wave rectification as shown in curve *b*, the average value $I_a = I_m/\pi = 0.318I_m$, and the effective value $I_e = I_m/2 = 0.5I_m$. That is, the effective value is 1.57 times the average value, and therefore, movable iron, electrodynamometer, and thermal type instruments will indicate about 57 per cent higher than the permanent-magnet, movable-coil type for the same current of this wave shape.

This ratio differs greatly according to the wave shape, and since rectified currents are seldom sinusoidal, the indication of the one type instrument cannot be computed from that given by the other type unless the wave form or form factor is known, which is usually not the case.

Polarized Vane Type. The polarized vane or needle type is often used on small rectifier sets for the measurement of the rectified current. This is the type of instrument used on automobile dashboards, which is familiar to all.

The instrument consists of a small iron vane or needle, pivoted in the magnetic field produced by a permanent-magnet, and polarized by it.

The current to be measured is passed through a coil which also acts upon the iron needle, but at right angles to the permanent-magnet field. The permanent-magnet maintains the needle normally parallel to its field, but when current is passing through the coil, the needle is deflected over a calibrated scale.

The peculiar feature of this instrument is that whereas the major portion of the deflection force is proportional to the first power of the current resulting from the action of the permanent magnetic field, there is a considerable percentage of the force proportional to the square of the current which arises from the fact that the current also tends to polarize the needle by acting directly upon it.

*The proof of these equations can be found in text books on alternating current.

To obtain correct indications when measuring pulsating currents, this type of instrument must be calibrated for a particular wave form, and in average or effective values according to the purpose for which the current is to be used, and it will not be correct for other conditions than those for which it was calibrated.

Practical Applications. Since, as stated above, the general types of instruments indicate differently on pulsating currents, it is necessary in each measurement to decide which is the correct one to be used. To show how this selection is made a few important specific applications will be considered.

Battery Charging. The amount of charge in a storage battery produced by the charging current is proportional to the quantity of electricity passed through the battery, usually measured in ampere hours. Since the quantity of electricity is equal to the average value of the current multiplied by the time the current has been passing, the proper instrument to use is one which measures the average value, that is, the permanent-magnet, movable-coil type.

As stated before, a polarized vane type may be used if calibrated to the particular wave form actually used, by using a permanent-magnet, movable-coil type instrument as a standard for calibration.

Electroplating. As in battery charging, the amount of metal deposited in plating baths is proportional to the quantity of electricity passed through them, so that for this purpose it is also necessary to use a permanent-magnet, movable-coil type of instrument.

Heating Appliances and Heating Effects in Circuits. In electrical heating devices and in circuits in general, the heat developed is proportional to the wattage produced in them, which is equal to I^2R, where I is the current and R the resistance which is considered constant throughout a cycle. Since, therefore, the heating effect is proportional to the square of the current, it is necessary to use a type of instrument the indications of which are proportional to the square of the current, that is, a movable iron, electrodynamometer, or thermal type.

Incandescent Lamp Loads. Considering a given lamp, when energized by various forms of current, as direct, alternating, or pulsating, the same candle power is produced when the filament is raised to the same temperature, that is, when it is supplied by heat at the same rate for the various currents. Since the heat is proportional to I^2R as in the preceding example, it follows that it is necessary to use a movable iron, electrodynamometer, or thermal type instrument to measure alternating or pulsating currents used for incandescent lamps.

Arc Lamps. From extensive researches on carbon arc lights by Mrs. Ayrton and others the following facts have been established:

The major portion of the illumination as well as a large part of the voltage drop across the arc occurs directly at the positive crater. This is about 35 volts and is practically independent of the amount of current

flowing. Further, the temperature and consequently the intensity of brilliancy are also nearly independent of the current. The increase in illuminating power produced by increase in current appears to be due to an increase in area of the crater, which increases at a slightly greater rate than the current. It has been found, therefore, that the illuminating power is nearly proportional to the first or a slightly higher power of the current.

From these facts it is evident that the value of a direct current which will produce the same candle power as the pulsating current is approximately equal to the average value of the first power of the instantaneous currents, and therefore, a permanent-magnet, movable-coil type instrument should be used in measuring the current. This is further substantiated by considering that the average power developed at the positive crater from which the major portion of the light emanates, equals the product of the average current and the voltage drop which is nearly constant at the crater. It follows, therefore, that to maintain the same average power for each cycle, the average current must be the same, and this is the current to be measured. It should be noted that in the examples previously given the instrument indications with pulsating current are exactly correct for the effect considered, but in the case of the arc light, the indications of the permanent-magnet, movable-coil type are approximately correct, but much more nearly correct than those of instruments operating according to the square law.

While the permanent-magnet, movable-coil instrument gives indications approximately correct in relation to illuminating or candle power of the arc when operated by pulsating current, its indications are entirely erroneous in regard to the heating of the carbons, rheostats, and other parts of the arc circuit outside of the arc itself. These heating effects are proportional to the squares of the instantaneous currents, and if these effects are desired to be known, a square law instrument should also be used. This also applies to battery charging and electroplating circuits. As stated above, the shape of the pulsating current wave is usually unknown, and is especially irregular in arc circuits, so that it is impracticable to estimate the heating effects from the same indications as used for the illuminating effects.

General Application. In the measurement of pulsating current, as already stated, it is necessary to consider each problem separately, but the method of attacking the particular problem can be stated generally. In each case it must be determined how the effect which the current is called upon to produce varies with the instantaneous values of the pulsating current recurring in its rapidly varying cycles, that is, whether it varies with the first power or the square law or some other law, and then choose the type of instrument which will indicate the average of the corresponding function of the instantaneous current values.

A few words of caution in the measurement of pulsating currents will not be amiss.

When using a permanent-magnet, movable-coil type instrument in which all or a larger part of the current passes through the movable coil, for measuring the average value of high-frequency, pulsating currents, or high-voltage, steep wave front currents from rectifiers, the instrument should be shunted by a condenser of about ¼ to ½ microfarad to prevent damage to the windings of the movable coil and also to give accurate indications. The presence of this condenser in no way affects the accuracy of the instrument calibration.

It is obvious that transformers can not be used in the measurement of pulsating current as they can not pass the direct current component.

It is sometimes desirable to know how much alternating current component is present in a pulsating current. To measure this it is necessary to use some form of selective a.-c. ammeter. With such an instrument the a.-c. component can be measured even when a very large d.-c. component is present.

Measurement of Power. The average power in watts or other units delivered by a pulsating current or absorbed by any device supplied with pulsating current is the average value of the product of the instantaneous values of current and voltage throughout a cycle. The usual form of electrodynamometer wattmeter, therefore, will indicate this power correctly regardless of the wave form, or whether the effect which the current is called upon to produce varies according to the first power or the square law, provided, of course, that the frequency is within the limits for which the particular wattmeter was designed. The limitations for pulsating current and the circuit connections are no different from those for ordinary a.-c. or d.-c. measurements.

This follows from the theory of the wattmeter. The deflecting forces are proportional to the product of the currents in the fixed and movable coils. The fixed coil carries the pulsating current and the movable coil a current proportional to the voltage, whether pulsating or constant. In a manner similar to that described under other tests, the moveable coil and pointer assume a position resulting from the average value of the products of these two currents, and, therefore, to the power in watts or other units of power.

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Beginning April 1st the Pittsburgh Office of the Stromberg Electric Company of Chicago, will be located at Room 426 of the new Grant Building, Pittsburgh, Pa.

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The Roller-Smith Company announces the following appointments: Jackson Brown, Jr., 701 Kittridge Bldg., Denver, Colo., as Sales Agent for Colorado, Utah, Wyoming and New Mexico; J. C. McDougall, Alaska Building, Seattle, Wash., as Sales Agent for Washington, Oregon and Alaska; Carl P. Lohr, 401 National Bank of Commerce Bldg., St. Louis, Mo., as Sales Agent for the St. Louis territory.

The Solenoid Accelerometer

*R. W. Brown**

THE need for a simple, rugged and compact instrument to measure the shocks imposed upon a motor vehicle by road irregularities has long been realized. It is important to know the effects of vehicle movement both as regards riding qualities and the momentary loads imposed upon the road or road impacts. Since the forces involved in the various movements of the motor vehicle are caused by changes in velocity, it becomes desirable to measure accelerations directly.

The present instrument was evolved after extensive experimentation and the construction of numerous accelerometers, such as the curve drawing carbon pile accelerometer, cantilever spring contact type and various spiral spring multiple element contact type instruments.

The solenoid accelerometer consists of six elements arranged in a case, as shown in Figure 1, which can be attached to the motor vehicle axle,

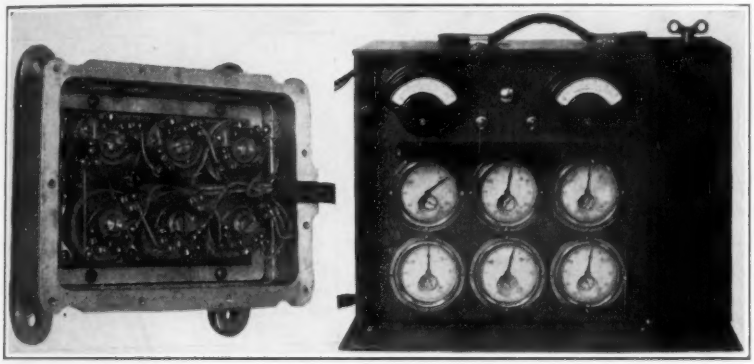

Fig. 1

Fig. 2

frame, seat cushion or other position where it is desired to measure accelerations. The elements are so arranged that a contact opens when the entire case is subjected to accelerations above the adjusted valve. The various elements are adjusted for different values of acceleration. The opening of the contacts operate a special counter, as shown in Fig. 2, thus after a test run has been made the counters indicate the number of accelerations which have occcurred above the adjusted value of the individual element. The adjusted value can be readily changed to anything desired by the manipulation of a rheostat incorporated in the counter case.

A diagrammatic cross section of an element is shown in Fig. 3. Current flowing through the iron clad solenoid (A) tends to pull the iron inertia

*In charge Engineering Laboratories, Firestone Tire & Rubber Co., Akron, Ohio.

weight (B) so that the contacts (C) remain closed with a definite force. The weight (B) is maintained centrally in the solenoid by the cantilever spring (D), which also serves as an electrical connection and the bearing (E). It is apparent that if the element is subjected to an acceleration along the axis of the weight (B) that the weight will tend to lag behind the movement. If the change in the velocity of the movement is sufficient, the force causing the weight (B) to lag will be greater than the force in the opposite direction exerted by the solenoid, hence the contact (C) will open, which causes the counter to register. Adjustments are provided on the upper contact and for the cantilever spring (D). Early experimental work indicated that the contacts would not open cleanly with any spring type of accelerometer but would tend to chatter, thus causing two or three count for one acceleration. With the solenoid instrument this difficulty is entirely overcome as the force exerted by the solenoid becomes less as the weight tends to move downwardly.

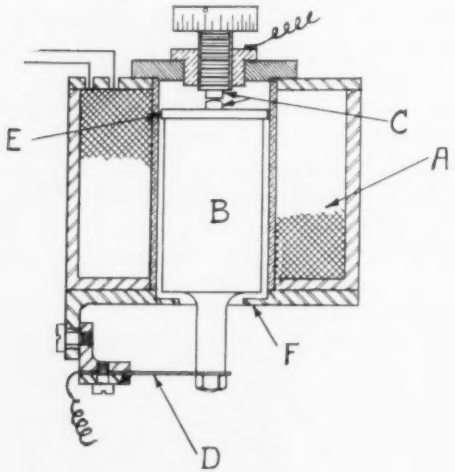

Fig. 3

It was found that commercially available counters could not be operated on the low current necessary to prevent pitting of the contacts. After much experimental work a polarized magnet was developed which would operate the escapement of a conventional clock mechanism sixty times per second on a total time opening for each count of 0.002 seconds with a current input of less than 0.1 watt.

A number of these instruments have been constructed and have proven practical in thousands of miles of service on all types of roads. While the instrument cannot be used to secure data to answer all conceivable questions regarding riding qualities and road impact, it has measured consistently and accurately in a practical manner the major accelerations occurring in motor vehicles in normal service.

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The Brown Instrument Company announces the appointment of two vice-presidents as follows: Charles H. Kerr, Vice-President and General Manager; George W. Keller, Vice-President and General Sales Manager.

A Super-Micromanometer

By John L. Hodgson, M. Inst. Mech. E.

IN 1924 the writer was asked by Professor Douglas Hay, who was a member of the Midland Institute Committee on the Ventilation of Mines, to design a micro-manometer for use underground, which besides being robust and portable should be at least ten times as sensitive as the well-known Chattock and Wahlen manometers.

As enquiries are now being received from research workers all over the world in connection with the manometer which was then produced, the writer feels that a brief description of it may prove of interest.

The manometer is shown diagrammatically in Fig. 1. Outside views are given in Figs. 2 and 3. Fig. 4 is a section through the displacer chamber.

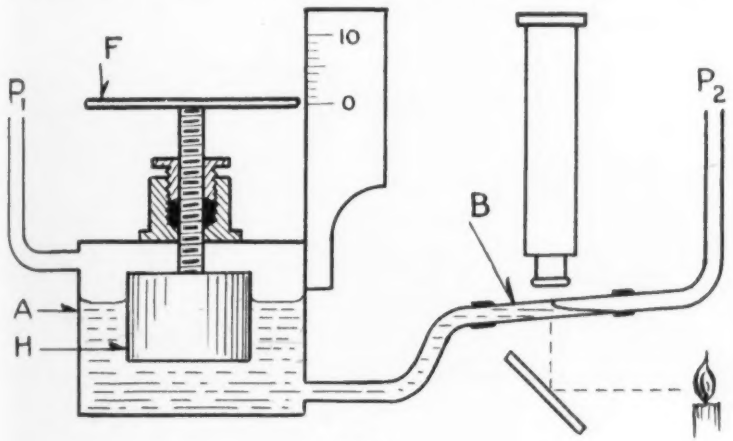

Fig. 1

A reference to Fig. 1 shows that the manometer consists of a displacer chamber A containing oil or other suitable liquid, which communicates with an inclined gauge glass B which is so placed with regard to the zero level of the oil in the reservoir that the upper meniscus of the oil in this tube is approximately at the centre of the gauge tube when the pressures between the two points P_1 and P_2 are equal. When the difference of pressure between P_1 and P_2 is increased, the meniscus moves to the right. It can, however, be brought back to the zero position by withdrawing the displacer H. The amount of this withdrawal is read on the fine dial F, and on the vertical scale provided.

It will be seen that theoretically this arrangement enables the most minute differences of pressure to be measured, as the displacer can be made of small section, and it can be raised and lowered on a fine screw thread. Actually, however, the accuracy which can be obtained in practice depends upon a number of factors other than the accuracy

with which the movement of the displacer can be read, such as the maintenance of the apparatus at a uniform temperature, and the exactness with which the position of the meniscus can be read. For measurements up to an accuracy of 1/10,000″ of oil, a simple gauge point as shown in Fig. 3 is adequate. The plug-cocks shown in that figure are also sufficiently satisfactory for work of this degree of accuracy. When, however, greater accuracies are desired, these plug-cocks must be replaced by leather faced cocks such as are shown in Fig. 4. These cocks are of large area and are absolutely leakproof in both the closed and in the open positions. If the passages through the upstream and downstream cocks are of small area, slight changes in the temperature of the air in the displacer chamber cause temporary inaccuracies in the reading, even though the cocks are fully open, owing to the expansion of this air and its consequent increase of pressure. Small leaks to "atmosphere" also introduce appreciable inaccuracies.

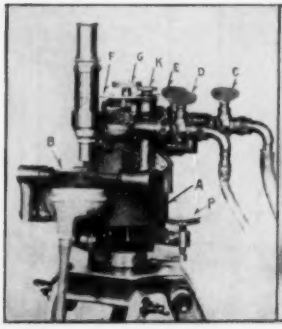

Fig. 2

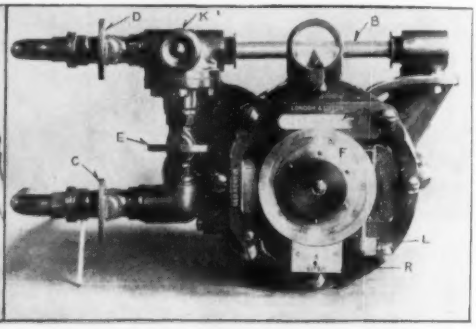

Fig. 3

For high accuracy it is therefore necessary to keep the displacer chamber at a constant temperature, to avoid leaks, and to make the cocks and pressure pipes of large area. It is also necessary to avoid appreciable differences of level between the manometer and the points at which the difference of pressure is being measured, lest differences of temperature in the pressure pipes themselves cause errors in the reading owing to differences of density of the air in these pipes.

By means of a microscope as shown in Figs. 1 and 2 the position of the meniscus along an inclined gauge tube half an inch in diameter can, if the meniscus is carefully illuminated, be read to 1/10,000″ of accuracy when a magnification of 1 in 60 is used in the eye-piece. A quite workable slope for the gauge tube is 1 in 10 (much finer slopes can be used if desired) so that the meniscus is easily read to an accuracy corresponding to a change in the oil level of 1/100,000″.

As previously explained, the reading of the displacer dial can without difficulty be made as fine as desired.

The instrument is designed to fit to a standard mining theodolite tripod, which provides a strong rigid base. In operation it is first carefully levelled, the inlet valves being closed. The equalising valve is then opened and the meniscus brought to zero in the gauge tube by rotating the milled head G which moves the displacer. This milled head is then held firmly and the graduated dial F (which is friction-

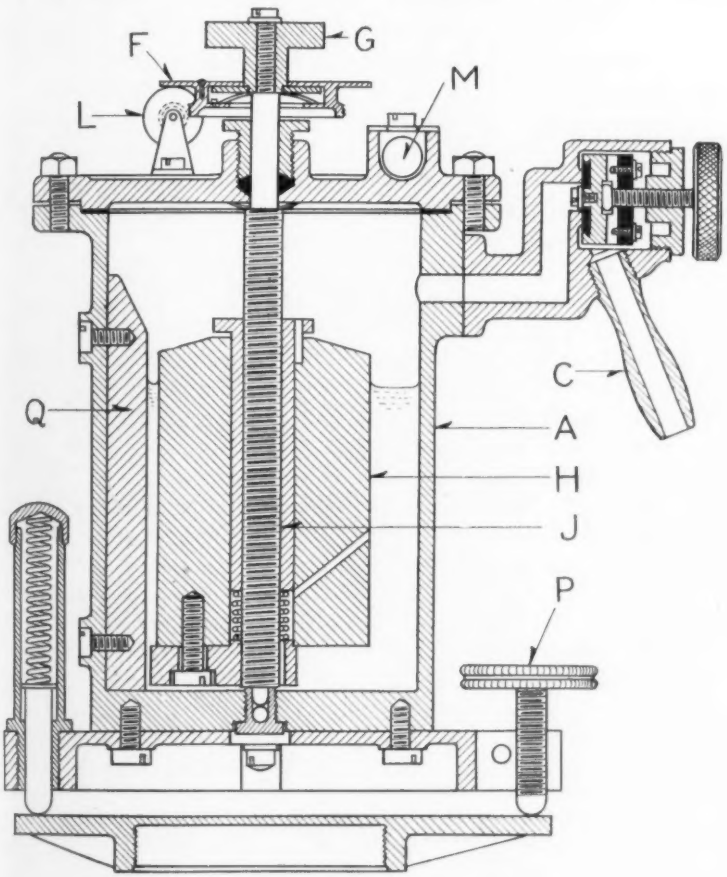

Fig. 4

tight on its spindle) is rotated to the zero mark on its scale. The equalising cock is now closed and the inlet cocks C and D are opened to pressure. The milled head is again rotated until the meniscus is brought back to zero, the amount of this rotation being measured by the fine dial F and the vernier R. A coarse dial L shows the number of revolutions made by the fine dial F. With the aid of the vernier R, 1/1,000th of a revolution of the dial F can be read. This, with the large displacer

supplied with the instrument, corresponds to a pressure difference of 1/10,000 inch of water, and with the small displacer to 1/100,000 inch of water.

The top of the vessel A is removable, and is kept in position by means of eight screws. The joint surfaces are carefully machined and are fitted with a washer. An air-tight joint is obtained by rubbing with vaseline before tightening down. When changing the displacers, care must be taken that the air-tight joint is maintained.

The following arrangements are provided for taking out all back lash in the displacer mechanism:

The screw spindle J is pressed by a spring washer against a steel ball trapped at its lower end.

The nut which travels on this spindle is made in two halves. The bottom half is fixed to the displacer, and the top half slides in it. This top half is prevented from rotating by means of a pin and a compression spring placed between the two halves aids the weight of the displacer and causes the lower half always to press on the upper surface of the screw threads.

Back-lash between the displacer H and the guide Q which prevents it from rotating, is taken out by means of a flat spring (not shown) which is screwed to the side of the lower half of the nut.

A vent K is provided for filling the vessel with oil. This is closed by means of a screwed plug fitted with a washer.

A removable pointer fitted with a white reflecting surface is provided to enable the instrument to be used without the microscope. For use with the microscope underground, ample illumination is provided beneath the meniscus by attaching a standard type of electric cap-lamp to the clip from which the pointer has been removed.

Sensitive spirit-levels are provided, one N being parallel to the gauge-tube and the other M at right-angles to it. A levelling-screw P enables the instrument to be levelled parallel to the gauge-tube, as it is essential that it should be kept accurately levelled in this direction. The instruments is mounted on a quick levelling-head in order to facilitate levelling.

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The Roller-Smith Company announces some additions to its sales organization.

Mr. Jackson Brown, Jr., 701 Kittridge Building, Denver, Colo., is representing the Roller-Smith Company in Colorado, Utah, Wyoming and Northern New Mexico.

The Manila Machinery & Supply Company, Inc., Manila, Philippine Islands, is representing the Roller-Smith Company in the Philippine Islands.

Both of these new representatives will handle the Roller-Smith Company's lines of electrical measuring instruments, relays and circuit breakers.

Some Magnetic Properties of Monel Metal

*By David R. Inglis**

"MONEL METAL," as described by the International Nickel Company in their booklet about that substance, "is not a synthetic alloy, but a natural combination of nickel and copper which is refined without changing the relation of the important elements, i.e., nickel and copper . . . . . The smelting and refining merely remove the undesirable elements. Monel metal contains approximately 67% nickel and 28% copper and 5% of other metals. This remaining 5% consists partly of iron from the original ore and partly of manganese, silicon and carbon being introduced in the process of refining."

The very extensive use of monel metal in the industries within the past thirty-five years emphasizes the need for a study of many of its physical properties. Some time ago Burrows[1] called attention to the fact that monel metal has definite magnetic properties. He found that at a magnetizing force of about 200 gausses (approximate saturation), cast monel metal (quenched) had a magnetic induction only one-twelfth of that of pure nickel, while annealed sheet monel metal had about one-third. Furthermore, the fact that monel metal has lost most of its magnetism by the time it reaches the temperature of boiling water makes it one of the very unusual alloys for a study of its various magnetic properties.

In an investigation[2] of the magnetostrictive effect in monel metal some very interesting results have been encountered. For example, a rod of the metal, when subjected to a magnetic field, changes its length as shown in Fig. 1. The changes in length for four different specimens are plotted against the various field strengths applied to them. 31 and 32 are for hot-rolled rods, 75 cm. long and 0.4 cm. in diameter, while 33 and 34 are for cold-rolled rods of the same dimension. The curve for number 32 is particularly interesting because it is in character very much like that of cast cobalt[3]. For convenience in plotting, the total change in length for these rods are given as ordinates for the graphs.

What is still more striking about the magnetostrictive effect is the after-effect. If the magnetic field is held constant at a strength of, say, 1000 gausses, the rod begins to shorten and continues to do so for several minutes. The amount of shortening for the first two minutes amount to 4 or 5 times that which occurred when the field was being varied.

*Fayerweather Laboratory of Physics, Amherst College, Amherst, Mass.

[1]Burrows, Elec. World, 76, p. 115, 1921.

[2]Williams, Phys. Rev., 29, p. 370, 1927.

[3]Honda, Magnetic Properties of Matter, p. 58, 1928.

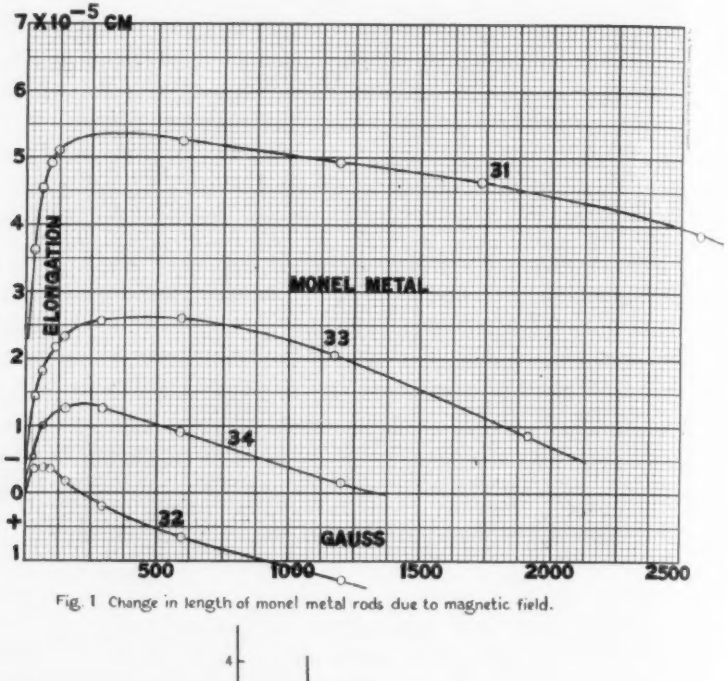

Fig. 1 Change in length of monel metal rods due to magnetic field.

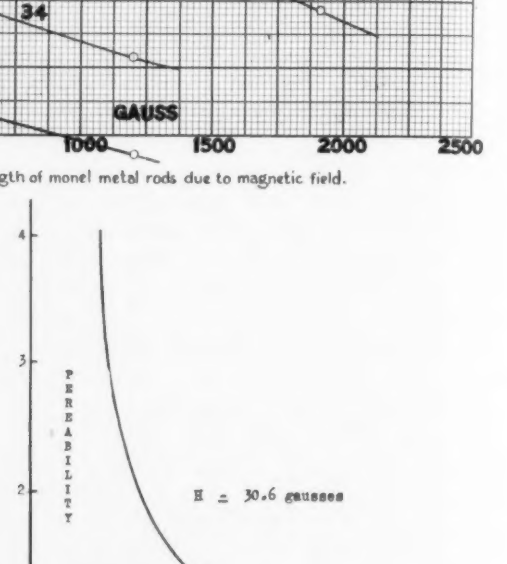

Fig. 2. The permeability of Monel Metal as a function of the temperature.

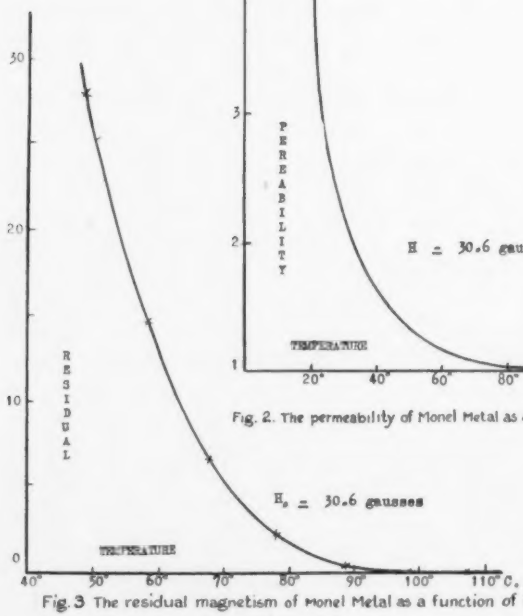

Fig. 3 The residual magnetism of Monel Metal as a function of the temperature.

In connection with the interpretation of this unique behavior, which was noted particularly in rod No. 32, it appeared desirable to investigate the manner in which rod No. 32, in particular, approached its critical temperature. Burrows[4] by a contact testing method determined the point where his method ceased to detect any magnetic susceptibility in monel metal. An average of several specimens gave him a value about 95°C. This he called the critical temperature.

Two methods were employed in studying the magnetization-temperature curves in this work,—magnetometric and oscillation methods.

1. *Magnetometric.* The specimen of monel metal lay horizontally at right angles to the magnetic meridian. The rod was surrounded by a slender, asbestos covered, electric furnace which fitted inside of a water jacket. Tap water circulated through this jacket. Outside of the furnace and the water jacket was the magnetizing coil. Near this outfit of specimen and coils, a fairly sensitive magnetometer was placed. When the specimen was not in position the effect of the magnetizing coil was just compensated at the magnetometer by an auxiliary coil in series with the main coil. When the rod of monel metal was in the coil, the deflection of the magnetometer was proportional to the intensity of magnetization of the metal. It should be noted at the outset that the susceptibility of monel metal is very small, so that no ordinary method of ferro-magnetic measurements can be used in the neighborhood of the critical temperature. The temperatures were determined by a mercury-in-glass thermometer. The magnetometer was checked by comparing the deflections at the same magnetizing forces as the rod had when tested at room temperature in a special ballistic permeameter whose constants were known.

Fig. 2 shows the values of the permeability of monel metal for different temperatures as worked out by this method. At 107° C. the permeability is 1.009, still sensibly greater than one. Just as in the other ferromagnetic substances, so in monel metal there is no allotropic transformation and no very sudden change of magnetic properties at the critical temperature.

Residual magnetism is a more certain criterion of the existence of ferromagnetism. Measurements of it were made by the method outlined above. Table 1 gives the numerical values of the intensity of residual magnetization of monel metal after a field of 30.6 gausses has been applied to the rod and then removed. These results are shown graphically in Fig. 3.

Table 1

Intensity	Temperature	Intensity	Temperature
0.285	48.6° C.	.0144	80.0° C.
.144	58.5° C.	.0042	87.7° C.
.065	68.3° C.	.0030	92.7° C.
.048	70.2° C.	.0022	97.5° C.
.0206	78.0° C.	.0016	107.2° C.

[4]Burrows, l.c.

From this data it is apparent that ferromagnetic properties decrease gradually with rise in temperature. This only demonstrates the indefinite nature of the transition at the critical temperature, and suggests that the exact determination of this point is dependent upon the sensitivity of the method, as well as upon the definition of critical temperature employed. The ferromagnetic character of monel metal seems to vanish mostly between 60° and 100° C. Somewhere within these limits lies the critical temperature.

2. *Oscillation.* Since higher temperatures could be used than were possible with the preceding method, it appeared to be of interest to see if there might be any discontinuities in the change of permeability with temperature, such as are known to accompany allotropic transformations in iron above its critical temperature. The same monel metal rod as was used in the preceding method was suspended horizontally and allowed to swing in a magnetic field. The permeability of the rod was approximately determined by observing its period of oscillation. Corrections were made for the small torque of the suspending fiber. The permeability decreased continuously as the temperature was raised from 20° to 400° C.

The author is indebted to Professor S. R. Williams for the curves showing the magnetostrictive effects in monel metal and for suggesting the main problem.

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THE MAINTENANCE OF INSTRUMENTS

Some of the reasons why instruments are not a success are:

1. The wrong type of instrument was purchased.
2. The instrument was not installed or used properly.
3. The instrument requires adjustment or correction.

In considering the purchase of instruments the following should be kept in mind:

1. Accuracy and sensitivity required.
2. Should the installation be indicating, recording or controlling or some combination of these.

The only way to have a successful installation is to make it definitely someone's business to look after the instruments. A little daily care will keep an installation in running order. The instruments should be kept clean and in good order, and every precaution taken to protect them from overheating and dirt.

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The Foxboro Company's Pittsburgh branch office will be located in the new Koppers Building after April 20th.

The Pittsburgh organization maintains a stock and service department in addition to its substantial sales organization, which equips it to render complete service to the industry.

New Instruments

Recently Developed by Instrument Manufacturers

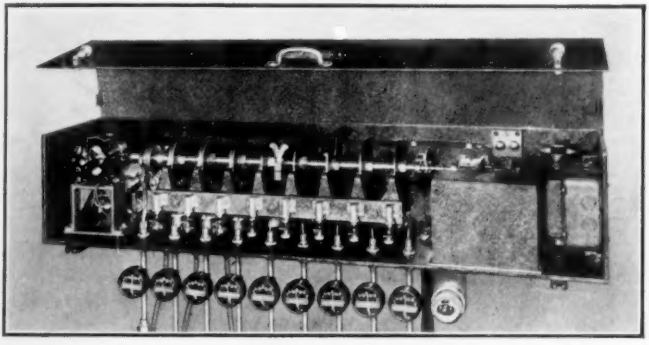
Write Information Section, Instruments Publishing Co., Pittsburgh, Pa., for additional information.

New Automatic Cycle Controller

(C. J. *Tagliabue Mfg. Co.*)

THE particular model of cycle controller illustrated consists essentially of a long rotating shaft on which are mounted a number of cams. Each cam controls the operation of a separate diaphragm valve or other such device. The last cam does not operate a diaphragm motor valve but has time graduations so that the progress of the operation can be determined at any time. In a controller which must perform more automatic operations a longer cam-shaft would be furnished. In fact, controllers of the cycle type can be built to handle practically any schedule of events.

The controllers are very substantially built. The case and frame are

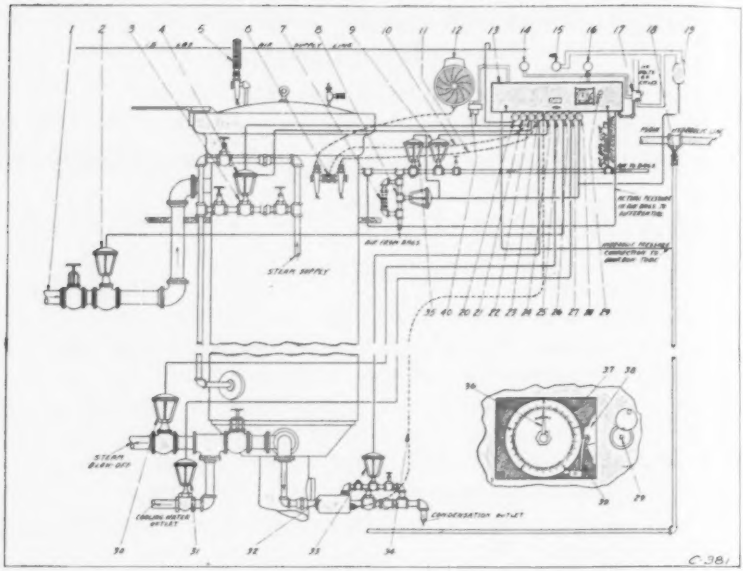


steel with an attractive crystallized lacquer finish. The pilot air valves, levers, cams and other mechanisms have been used in Tag controllers for many years and the dependability of these standardized parts has been well established by thousands of installations.

The following illustration shows the Tag automatic cycle controller applied to the curving operation in a tire factory.

The rubber company's specifications were: "Fill air bags in five minutes; one minute to test for air leakage in bags (5-lb. drop permissible); thirty minutes to rise to vulcanizing temperature; two hours to hold at this temperature; three minutes to blow down steam; thirty minutes opening of water inlet and water draining for cooling; ten minutes to warm molds to facilitate removal of tires. And throughout the entire cure, whenever the hydraulic pressure drops from 1500 lbs. to 1200 lbs., the controller shall automatically relieve the bag pressure."

Three signal lamps are connected to the controller. A white lamp is connected to the current supplied to the controller. If this light goes out



WHITE Light 14 shows that controller current is ON.

GREEN Light 15 indicates end of curing operation.

RED Light 16 indicates air bag leakage. As soon as it flashes, the electric clock operating cam 18 for air leak test stops, and cure DOES NOT proceed until attendant performs following operations:

(a) Opens by-pass valve 7 on air outlet line from bags.

(b) Closes hydraulic hand valve 18, removes the cover from the press; finds and stops air leakage; closes press.

(c) Opens hydraulic hand valve 18.

(d) Closes by-pass valve 7 on air outlet line from bags.

(e) Inserts special key into stud 29 and turns cam 18 until point of lever 19 is on white line of cam 18.

Controller again automatically tests for air leakage, continuing if no leak—but again flashing red light if air bags leak.

1—Cooling water supply line.
2—Direct acting D. M. Valve on cooling water admission line.
3—Direct acting D. M. Valve on steam admission line.
4—Duplex top of steam admission valve 3.
5—TAG Industrial Thermometer.
6—TAG circulation fitting for bulbs.
7—Hand valve on air discharge from bags.
8—Direct acting D. M. Valve on air bag pressure discharge line.
9—Direct acting D. M. Valve on air bag pressure admission line.
10—Principal tube system for control of steam admission.
11—Safety or emergency tube system for control of steam admission.
12—TAG Recording Thermometer.
13—The TAG Automatic Cycle Controller.
14—White light flashes when current is being delivered to controller.
15—Green light flashes when cure has been ended.
16—Red light flashes when air bags leak.
17—Main electric switch to motor and the two Warren clocks.
18—Hand Valve on hydraulic pressure line to ram.
19—Snapon Controller flashes green light when D. M. Valve opens at end of cure.
20—Gage indicates available air pressure (should be 15 lbs.).
21—Gage indicates operation of valve 3.
22—Gage indicates operation of valve 5 by means of duplex top.
23—Gage indicates operation of valve 11.
24—Gage indicates operation of valve 9.
25—Gage indicates operation of valve 10.
26—Gage indicates operation of valve 2.
27—Gage indicates operation of valve 11.
28—Gage indicates operation of valve 8.
29—Setting stud for air leak test cam.
30—Direct acting D. M. Valve on steam blow-off line.
31—Direct acting D. M. Valve on cooling water outlet line.
32—TAG Condensation Chamber.
33—Direct acting D. M. Valve on condensation line.
34—Condensation tube system.
35—Reverse acting D. M. Valve on air bag pressure admission line.
36—Pointer showing position of main cam shaft.
37—Time dial.
38—Cam for air leak test.
39—Lever for mercury contact.
40—Snap on automatic switch for cam shaft clock.

it would indicate failure of the electric current driving the clocks and resetting motor. A red lamp is lighted if the air leak test shows excessive bag leakage and it stays lit while the controller is stopped for correction of this condition. A green lamp is lighted at the final termination of all operations.

The use of Tag cycle controllers is not limited to tire presses. Various models of the controllers are being installed—for mechanical goods platen presses, high speed individual tube vulcanizers and other production apparatus, where both "speeding up" and "maintenance of quality" are equally stressed by managerial policies.

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Time and money can be saved by reading Instruments' Advertising Pages as often as its editorial pages. That is because all advertising in INSTRUMENTS is vouched for by the company whose name is on the advertisement.

A Direct Reading Thermocouple Temperature Indicator For Electrical Machinery

F. S. Stickney *

A DIRECT reading temperature indicator for use with imbedded thermocouples in electrical machinery has been much in demand by those designers and operators who recognize the desirable features of the thermocouple as a means of temperature measurement. In measuring the hot spot temperatures of electrical machinery, especially large motors and generators, the reliability of the temperature measuring equipment is of prime importance. Much has been written concerning the relative merits of imbedded resistance coils versus imbedded thermocouples, but the facts remain that where high temperatures are involved, where space is limited, or where complex insulation problems exist, the imbedded thermocouple has many points in its favor. Its size and construction can be varied more widely to agree with the type of winding used in the machine, and in case the machine is designed for high temperatures, the thermocouple can be more readily insulated with asbestos, mica, etc., than can an imbedded resistance coil.

The use of imbedded thermocouples has been somewhat limited in the past by lack of good measuring instruments. Operators are naturally inclined to favor a direct reading instrument rather than one of the potentiometer type which requires manipulation before readings are taken. The potentiometer method of reading temperature by thermocouples, in spite of its inherent advantages of accuracy and of being independent of lead resistance, is being gradually superseded by the direct reading switchboard temperature indicator.

Electrical machinery is seldom operated at temperatures above 150° Centigrade. At this temperature a copper to copper-nickel thermocouple develops an E.M.F. of between 5 and 6 millivolts with its cold junction at ordinary room temperature. This voltage is ordinarily too low to be accurately measured by the usual switchboard indicating instrument. Another serious problem is that of compensating for cold junction temperature. A third and no less important problem is that of providing correction for the ever-present variations in the resistance of thermocouples and wiring. In discussing the solution of the problem, three divisions will be made; first, a discussion of the millivoltmeter and its characteristics; second, the solution of the problem of compensating for cold junction temperature; and third, the solution of the problem of lead resistance compensation.

*Relay and Meter Engineer, Westinghouse Elec. & Mfg. Co.

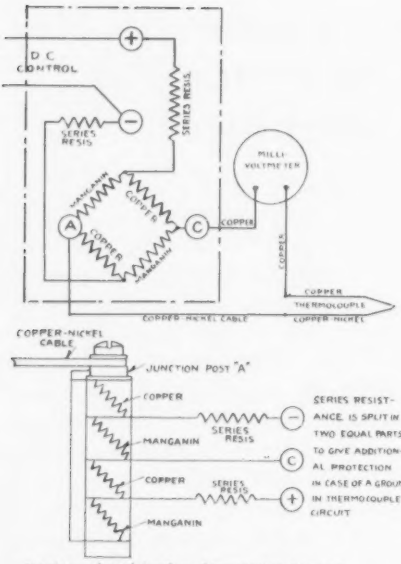
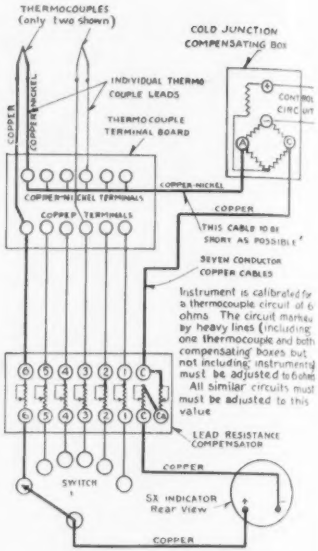
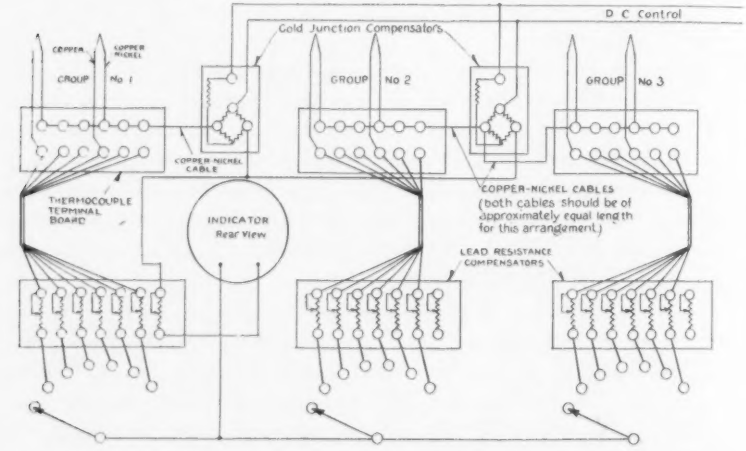


Diagram of Cold Junction Compensator Showing arrangement of Junction Post and Windings
Fig 1


THERMOCOUPLES (only two shown)
COLD JUNCTION COMPENSATING BOX
INDIVIDUAL THERMO COUPLE LEADS
THERMOCOUPLE TERMINAL BOARD
COPPER
COPPER-NICKEL
COPPER-NICKEL TERMINALS
COPPER TERMINALS
COPPER-NICKEL
COPPER
THIS CABLE TO BE SHORT AS POSSIBLE
SEVEN CONDUCTOR COPPER CABLES
Instrument is calibrated for a thermocouple circuit of 6 ohms. The circuit marked by heavy lines (including one thermocouple and both compensating boxes but not including instruments must be adjusted to 6 ohms. All similar circuits must be adjusted to this value
LEAD RESISTANCE COMPENSATOR
COPPER
SWITCH
SX INDICATOR Rear View
COPPER

Wiring Diagram—Type SX Thermocouple Temperature Indicator
Fig 2



Method of reading temperatures of several groups of thermocouples on a single indicating instrument.
Fig. 3

The millivoltmeter has the appearance of an ordinary switchboard instrument, 7½ inches in diameter with a scale 3½ inches long. A balanced design has been obtained by usual methods; i.e., by improving each detail to the point of maximum usefulness. The winding is designed as efficiently as possible. The springs are as weak as is consistent with good performance. The magnet is as strong as can be obtained in the space

available. The moving element is made as light as possible to permit reduction in torque without causing pivot friction. A reasonable amount of manganin has been left in the circuit to eliminate temperature coefficient. Special pole-piece design develops maximum efficiency from the combination. The scale is calibrated 0-200° Centigrade, giving a working sensitivity of more than 1/64 inch of scale per degree Centigrade. The scale can be easily read to the nearest degree.

An electrical method of cold junction compensation is used. A cold junction compensating box is located at or near the thermocouple terminals of the machine, thus reducing to a minimum the amount of alloy cable in the thermocouple circuit. The copper-nickel sides of all thermocouples are connected together at the thermocouple terminal board, and a single copper-nickel lead is run to the cold junction compensator usually located close by. A separate d.-c. control circuit is applied to the compensating box, maintaining the cold junction electrically constant as will be described later. The circuit is completed through the instrument with copper cable, and the instrument may be located in any desired place without affecting its sensitivity or accuracy.

The diagram of the cold junction compensating box is shown in Fig. 1. A bridge circuit consisting of two copper arms and two manganin arms is compactly wound from a heavy metallic junction post A. The cold junction is formed at one end of the post by contact with the copper-nickel lead from the thermocouples. Constant current is passed through the bridge from a constant potential circuit, the current being determined by a self-contained resistance in the compensating box. Any voltage from 1 volt to 600 volts may be used for the control circuit. The most commonly used voltages are 24 volts, 125 volts, and 250 volts. The potential from ordinary storage battery equipment or from an exciter circuit is very satisfactory for the purpose, as will be explained later.

Due to the considerable mass of the junction post A, the temperature of the bridge windings is the same at all times as the temperature of the cold junction. The e.m.f. across the diagonal corners of the bridge is proportional to the temperature of the bridge on account of two of the windings being made of copper which has a considerable temperature coefficient of resistance. This e.m.f. is added algebraically to the e.m.f. developed by the two junctions of the thermocouple in such a way that the effect of any variation in the temperature of the cold junction is completely nullified.

Since variations as great as $\pm 20\%$ are to be expected in the voltage of a d.-c. exciter circuit, or in a battery circuit which might be available for a power plant installation, it is necessary that the effect of this variation in voltage be reduced to a negligible value. This has been accomplished by designing the bridge of the compensator for balance at the ordinary room temperature of 30° C. At this temperature, the resistance of the copper arms of the bridge is equal to that of the manganin arms

Therefore, no e.m.f. is developed by the compensator at 30°, and the current flowing in the thermocouple circuit is due to the e.m.f. of the thermocouple alone. If both the hot junction and cold junction were at the same temperature under these conditions the thermocouple would develop no e.m.f. and the deflection of the millivoltmeter would be zero. The spring zero of the millivoltmeter is therefore made at 30° C. on the dial, which corresponds with the balance point of the bridge in the compensator box. Assume now that the temperature of the hot junction is increased from 30° C. to 100° C., all other conditions remaining the same. According to the temperature—e.m.f. curve for a copper-to-copper-nickel thermocouple, the e.m.f. developed by the thermocouple will be 3.04 millivolts when the hot junction is at 100° and the cold junction at 30° C. The millivoltmeter is accordingly calibrated so that a voltage of 3.04 millivolts will move the pointer from its true spring zero at 30° C. up to the point on the dial indicating 100° C. Now assume that the temperature of the cold junction falls from 30° C. to 25° C., the temperature of the hot junction remaining at 100° C. The e.m.f. developed by the thermocouple will increase from 3.04 millivolts to 3.24 millivolts. Without compensation this would cause the pointer to move further up the scale and indicate approximately 105° although the true temperature at the hot junction is still 100°. To offset this, however, the temperature of the bridge winding falls to 25°, unbalancing the bridge so that .20 millivolt is subtracted from the e.m.f. developed by the thermocouple. The millivoltmeter operates upon the difference between the two voltages and indicates the corresponding temperature, i.e., 100° C. which is the true temperature of the hot junction.

Now a word regarding the accuracy of the compensator under varying control voltage. Since the balance point is 30° C. the compensator is entirely independent of control voltage at this temperature. At any other temperature the error in degrees C. is equal to the difference between 30° C. and room temperature, multiplied by the percent of variation of control voltage from its nominal value. For example, if cold junction temperature is 25° C., the difference between 30° and 25° is 5° C. If the control voltage should be decreased or increased 20% volts under these circumstances, the error would be 20% of 5° or 1° C., which is ½ of 1% of the full scale reading of the indicator. It is ordinarily possible to obtain control voltages with much better than ±20% regulation, so as long as the temperature of the cold junction compensator remains reasonably close to 30°, error from variation in control voltage can be neglected.

Commercial imbedded thermocouples vary considerably in resistance. Even in the same machine the resistance of individual couples may vary more than 50% due to the fact that thermocouples located on all sides of the machine are usually brought out at a common terminal board for convenience. In addition, the circumstances of location attending each

application are different. Both the distance between indicator and thermocouple and the cross-section of cable used vary with the installation. Only by use of an extremely high resistance millivoltmeter could these variations be neglected, and the design of a high resistance indicator for such low operating voltages is impractical without departure from the usual construction of moderately priced switchboard instruments. For this reason it has been found desirable to use a low resistance instrument, and to provide additional means for compensating for variations in the resistance of thermocouple circuits. Accordingly, the millivoltmeter is

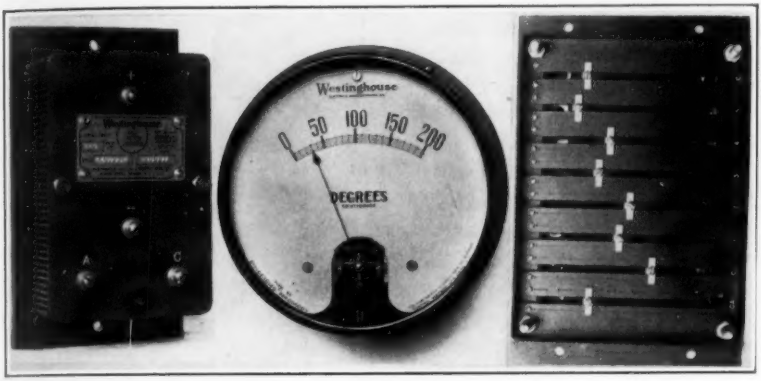


Fig. 4 Fig. 5 Fig. 6

Fig. 4. Cold junction compensator. Fig. 5. Westinghouse type SX temperature indicator. Fig. 6. Lead resistance compensator showing adjusting slides.

calibrated for use with an external circuit resistance of 6 ohms. This external circuit includes the thermocouple, all wiring, the bridge windings in the cold junction compensating box, and an adjusting rheostat. The resistance of the circuit, or of each circuit where several circuits are used, is adjusted to 6 ohms by means of slide wire rheostats assembled in a lead resistance compensating box. This adjustment is made at the time of installation, and once it is fixed no further adjustment is necessary. A portable Wheatstone bridge for measuring resistance is recommended for making this adjustment. If the hot junctions are above room temperature during this resistance adjustment, the mean of two reversed readings of the Wheatstone bridge should be taken as the true value to eliminate any error which might be caused by the e.m.f. of the thermocouple. The indicator can also be adjusted with a portable potentiometer as a standard instead of a portable bridge.

Figure 2 shows a typical diagram for the indicator when used with a machine having 6 imbedded thermocouples. The 7 circuit lead resistance compensator is clearly shown. The copper side of each thermocouple is brought through a separate conductor to the lead resistance compensator, where all circuits are adjusted to equal resistance. The

seventh rheostat, which is really two rheostats in series in the return circuit, is used for bringing all circuits to the correct value of 6 ohms.

In large power plants it is sometimes desirable to measure the hot spot temperatures of an entire group of machines upon one indicator. The connections for this arrangement are shown in Fig. 3. A separate dial switch is required for each machine or group of thermocouples, and each switch should be connected with one idle point, or else an additional group selector switch should be provided. Due to the high resistance of copper-nickel cable and the considerable distance existing between machines, it is usually advisable to provide a cold junction compensating box for each group of thermocouples, as shown by group No. 1 in Fig. 3. An exception to this rule may be taken when the cold junction compensating box can be located approximately midway between two machines, as in groups 2 and 3 in Fig. 3, or located centrally in a group so that approximately equal lengths of copper-nickel cable may be used between the compensating box and the respective machines. In either event it is necessary to provide enough lead resistance compensating rheostats to take care of each thermocouple circuit individually. The lead resistance compensating rheostats may be located anywhere in the thermocouple circuit, although the usual practice is to locate them on the instrument panel where they me be readily adjusted by inserting a portable bridge in place of the indicating instrument.

It is believed that the convenience and reliability of the imbedded thermocouple, together with the ease of operation, freedom from trouble, panel where they may be readily adjusted by inserting a portable bridge for this type of direct reading temperature equipment.

——— :: ———

The general impression is that alarm clocks are comparatively modern inventions. As a matter of fact, an effective alarm clock, guaranteed to awaken the soundest sleeper, was devised nearly three centuries ago. In this ancient timepiece the rays of the sun, concentrated through a magnifying glass, discharged a small cannon precisely at noon. The brass cannon was firmly mounted on a marble base and was wound up by loading with a teaspoonful of powder. Above the cannon was placed a burning glass mounted on struts, which could be adjusted to "strike" the noon hour correctly at various months of the year. The touch hole of the cannon consisted of a groove which paralleled the north and south line of the dial, so that at noon the sun would be focused on the powder and make the primitive alarm clock strike.

The first mechanical device for telling the time was doubtless the clepsydra, or water clock, which appeared in Greece two centuries B. C., and was probably used even earlier in Babylon and China. The simplest form of water clock consisted of an earthen vessel with a small hole in the bottom through which the water trickled, while the height of the water marked the hour.

Type OB Watthour Meters

Alternating Current

(Westinghouse Electric & Mfg. Co.)

Fig. 1
Single-Phase OB Watthour Meter

THE real advantages of a watthour meter are determined by the following factors: Its ability to register accurately under all load conditions; its ability to maintain this accuracy for long periods of time with minimum attention and expense; its reliability; low internal losses; its independence of normal variations of temperature, voltage, power factor, wave form, and frequency; its independence of external magnetic disturbances, or abnormal vibrations; its ability to start at very light loads, and its capacity for overloads. A meter should also be of light, compact and strong mechanical construction, easy to install and easy to test.

The OB meter is so designed electrically that it meets the above requirements, and so designed mechanically that it cannot easily be thrown out of adjustment. These qualities give it the important characteristics of being able to maintain its initial high accuracy for long periods of service with little or no attention and maintenance expense. The accuracy is especially high at the lower end of the load curve, as it should be, because for the greater part of the time the actual load on a meter is but a small percentage of its capacity. Some of the factors which have resulted in these important characteristics are: refinements of the design of the bearings, moving element, electromagnets, permanent magnet, register, and case construction.

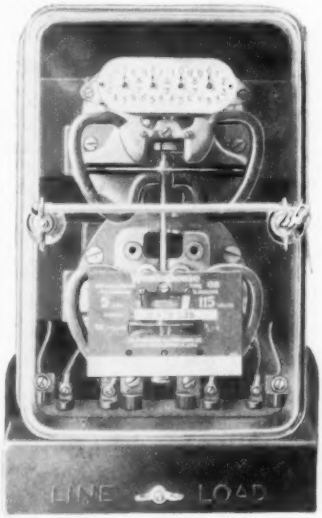
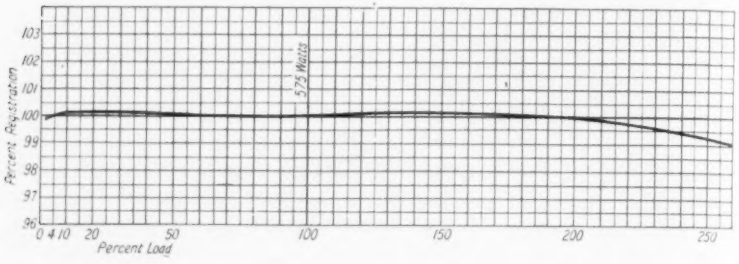


Fig. 2
Polyphase OB Watthour Meter

Low friction and the efficient hysteresis characteristics of OB meters enable them to accurately register the smallest loads, such as bell-ringing

transformers, motor-operated clocks, etc. OB accuracy is not affected appreciably by varying voltage or frequency. A 10 per cent change in voltage will not affect the accuracy of the OB meter more than 0.3 per cent, and the maximum error for a 10 per cent change in frequency is less than 0.5 per cent in a 60-cycle meter.

OB electromagnets are uniform, a characteristic which permits the use of a fixed power-factor compensator in single-phase meters. This gives correct compensation within ± 1½ per cent on power factors between 50 per cent lagging and leading. In polyphase meters the power-factor compensator is adjustable, but it is necessary only to check the power-factor compensation initially, the adjustment then remaining fixed until purposely changed.



OB meters are remarkably accurate over their entire range. The curve reproduced here shows that all of the energy delivered to the consumer is registered. Permanent temperature compensation, both in the electromagnet and in the permanent magnet, is obtained by a method utilizing the physical change of materials with change of temperature.

OB watthour meters operate on the induction principle. In a perfect meter the driving torque would be exactly proportional to the product of the voltage, current, and power factor of the circuit, and the retarding force would be exactly proportional to the speed—friction being absent—in which case a direct ratio would exist between the speed and the energy passing through the meter, thus giving it absolute accuracy throughout its entire load range. The more perfect a meter is, the greater will be the percentage of work expended usefully in driving the disc, and the more direct will be the ratio between the speed and the energy passing through the meter at all loads.

The OB meter more nearly approaches the perfect meter because of (1) its high ratio of torque to friction, due to more perfect bearings and registering mechanism; (2) more constant ratio between energy and torque, due to more efficient design of the electromagnet; and (3) more direct ratio between effective torque and speed, due to the use of magnets made of special steel, treatad, formed and aged by processes which assure permanency under the most severe service conditions.

New Type Ultra-Microscope

(E. Leitz, Inc.)

IT is well known that the resolving power of microscopes have their limitations since they are dependent upon the wave length of the illuminating rays and the numerical aperture of the objective for their necessary resolution. The Ultra-Slit Microscope is intended to serve in making visible such minute particles falling below the resolving power obtainable with microscopes.

It is in this direction that the Leitz Works have occupied themselves for quite some time in constructing a special Ultra-Microscope which will offer renewed stimulus towards the quantitative measures of colloid particles and will furthermore, make it readily possible to have available an instrument for micro studies with Ultra-microscopical specimens.

The principal features of the new Ultra-Microscope are: it permits the examination of solutions as well as solid substances, improved type of optical bench giving free access to all table space; minimum of adjustment; improved pattern arc-lamp; adjustable and orientating slit reading to 0.1 mm; calculated depth of illuminated stratum in preparation permitting an eye-piece micrometer to be used and to calibrate the cubic measurements of the field of view.

A quartz cell free from cement and easily cleaned, as well as ample space for polarizer and accessories, are available. The apparatus is simple to manipulate, having definite index mark for its proper operation. The illustration shows that the Ultra Microscope has but one movable component on the optical bench instead of the usual elaborate and complicated arrangement which prevailed in the past.

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The May issue of INSTRUMENTS can be of service to you in making it possible for you to reach an exceptionally large number of prospects, whether or not you attend the

Twelfth Exposition of Chemical Industries

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A New Directional Relay

By C. L. Lipman, A.M.I.E.E.

A CAREFUL study of modern extra-high-voltage practice has revealed the necessity for new and improved protective gear and relays, for experience has shown that the success of any protective scheme depends largely on the reliability and suitability of the relays employed.

Amongst protective relays, the directional type is the most important; it covers a wide and varied field of application, and, in view of the important improvements which have recently been introduced into this class of apparatus, its uses will undoubtedly be still further extended.

The new device is reliable and sensitive and offers a satisfactory solution to practically all modern problems involving the use of Directional Relays. It will select as to the direction of current flow, even should the voltage drop to as low as 1% of the normal, and when properly connected to a three phase system, it will operate correctly, no matter how abnormal the phase relations between the current and voltage vectors may be during a short circuit.

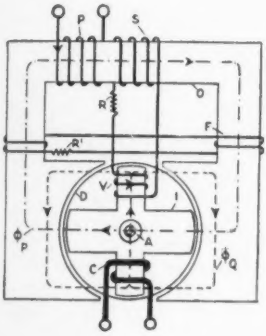

Fig. 1

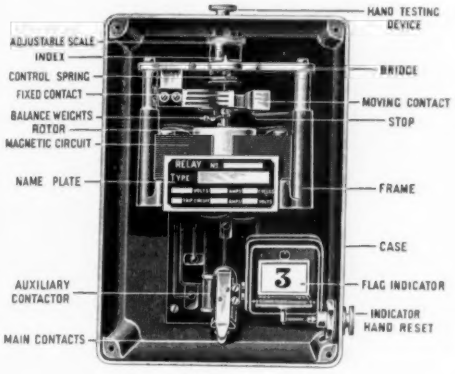

Fig. 2

The magnetic and electric circuits are illustrated in Fig. 1. The rotor D is in the form of a cylindrical cup which is free to rotate in the air gap between the poles of internal and external electromagnets I and O respectively; P is the main potential winding, C the main current winding; V the voltage compensating winding; F are power factor compensating windings; R and R_1 are resistances for calibration purposes. It will be noted that coil v is energized inductively from the main potential winding, and that coils F form a closed circuit of their own. The resultant potential flux ΘP circulates along the path indicated by the chain line, thus acting upon the rotor D in a horizontal direction, whilst the flux ΘQ, due partly to the current coil C and partly to coil V, acts upon the drum in a vertical direction, i.e. at 90 geometrical degrees to

that of ΘP. The resistance R^1 is so adjusted that the fluxes ΘP and ΘQ are also electrically displaced by 90 time-phase degrees. These conditions being satisfied a turning moment is exerted upon the moving system by the combined action of fluxes ΘP and ΘQ. The polarity of the coils C & P is such that with forward power they tend to hold the moving system, and with it one of the relay contacts, against a stop, i.e. in the inoperative position.

On the reversal of power the tendency to rotate is in the opposite direction, and if the reversal reaches the value of the reverse current setting the contacts will close and the relay will operate. The action of coil V is unidirectional, and its effect is to assist, or oppose the current coil C according as the flow of current in the controlled circuit is in the forward or reverse direction, respectively. It follows, therefore, that at normal voltage, the reversal will increase until it is sufficient to overcome the

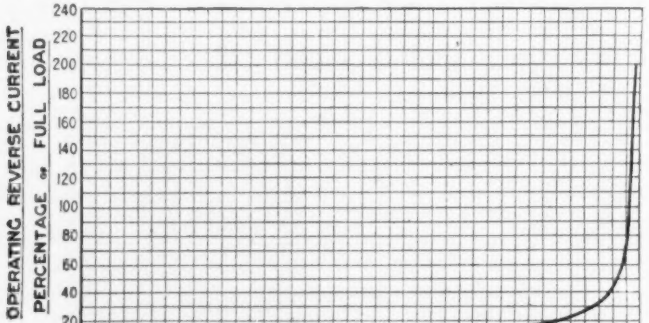

Fig. 3 Curve showing sensitivity of Type L.1 Relay at low voltage.

neutralizing effect of coil V before the relay will operate. When, due to a short circuit, the voltage drops, the neutralizing effect of coil V is correspondingly reduced, the relays thus becoming more sensitive.

Matters are so adjusted that the energy required to operate the relay decreases proportionately with the voltage, so that the reverse current calibration, whatever the selected percentage value may be at normal voltage, remains practically constant for all voltages down to about 1/6th of the normal, hence the name "Reverse Current Relay." The characteristic curve (Fig. 3) shows that operation is practically independent of the voltage of the controlled circuit.

A number of these relays have been installed with current coils wound 5 amperes normal (Secondary) current (= 100 per cent) and set to operate with only half of 1 percent reverse current at normal pressure, the volt-ampere consumption of the current coil at this setting being of the order of 0.0013. For ordinary purposes, however, this relay has been

standardized to operate with a 15 per cent reverse-current setting, consuming less than 1 volt-ampere at a full-load current of 5 amperes, the volt-ampere consumption of the pressure coil being about 3.5 V.A. at 110 volts 50 cycles.

It will be noted that the load which the new relay windings place on the current and voltage transformers is so small that the accuracy of the meter installed in the same circuit is not affected. The new relay has in fact, been specially designed to work in conjunction with brushing-type current transformers of limited primary ampere-turns, and in this respect it is unique in its applications. The complete relay is illustrated in Fig. 3 (with cover removed). It is fitted with an auxiliary contactor of an improved design, the main contacts of which are capable of dealing with a trip circuit up to 2,600 watts, i.e. 10 amperes at 260 volts. The moment the relay contacts close circuit the auxiliary contactor operates and the process of tripping the main switch must go on until the latter is opened. The relay is self-resetting and is fitted with an electrically-operated hand replaceable flag indicator which gives a positive indication of its having operated; it is also provided with hand testing and anti-vibration devices, other advantages being high working forces, combined with robust construction.

The standard relay is of the instantaneous pattern, but that illustrated in Fig. 2 is fitted with the Nalder-Reyrolle inertia cup which, when loaded with flat disks introduces a short inverse time-delay action. When sequential operation is required by means of time discrimination, the relay is provided with a time lag device which gives inverse characteristics for ordinary overloads and definite minimum time characteristics under short circuit conditions.

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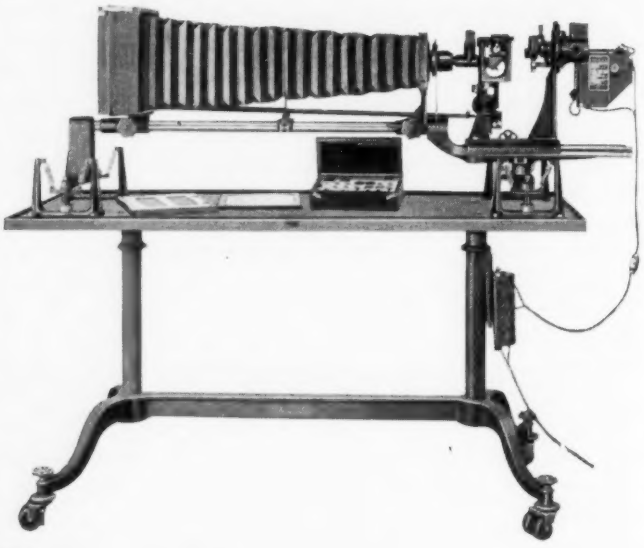

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Automatic Control of Chrome Plating Tank Temperatures

Bulletin 376, issued by The Bristol Company, Waterbury, Conn., describes their automatic temperature control for holding temperature constantly uniform, insuring most efficient chrome deposit.

A Sure Hand on Heat Control!

is the title of Circ. F-73-P 325-129 illustrating the L. & N. Potentiometer Pyrometer. This is available on request to Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

Automatic Frequency Regulation

A reprint from the Electrical World on Automatic Frequency Regulation is being distributed by Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

Automatic Electric Control Valves

Catalog No. 2000 describes the Automatic Electric Motor Operated and Magnet Type Control Valves manufactured by The Bristol Company, Waterbury, Conn.

Chemist-Analyst

The March 1st issue of the Chemist Analyst published by J. T. Baker Chemical Co., Phillipsburg, N. J., contains many articles of interest to chemists.

Distance Reading Tank Gauges

The Liquidometer Corp., Skellman Ave. & Hulst St., Long Island City, N. Y., have issued a bulletin describing their instruments for indicating and recording tank contents.

Diffraction Gratings

Bulletin Rooster 28 issued by P. J. Kipp & Zonen, Delft, Holland, gives information on Diffraction Gratings.

Distance Thermometers

Negretti & Zambra, 38 Holborn Viaduct, London, EC1, England, have issued a Bulletin covering pressure spring thermometers manufactured by them.

Enclosed Circuit Breakers

Bulletin No. 580 of Roller-Smith Company, 233 Broadway, New York, N. Y., describes their new type EAF enclosed circuit breaker.

Economical Production of Gas

Publication TM-2 issued by Cutler-Hammer, Inc., Milwaukee, Wis., contains the following: The Thomas Meter; The Thomas Calorimeter; C-H Automatic Gas Mixing Control System; C-H Total Heat Meter; C-H Total Heat Controller and C-H Valve Control.

Evolution of the Testing Machine

is the title of a booklet issued by Riehlé Bros. Testing Machine Co., 1424 N. 9 St., Philadelphia, Pa. It gives a history of their company founded in 1825.

Gas Service Journal

The February issue of the Gas Service Journal, published by the Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa. It contains: Metering Industrial Gas at Waterloo, Iowa; Columbia System Gas Scientifically applied in the Ceramic Industry; Natural Gas Boilers; Method of Testing Positive Meters using a 3-way stop.

General Radio Experimenter

The March issue of the Experimenter issued by the General Radio Co., Cambridge, Mass., has interesting articles on Frequency Determination and a Better Frequency Meter for the Amateur.

Hytempite

Quigley Furnace Specialties Co., 26 Cortlandt Street, New York, have issued Bulletin No. 252 on Hytempite, the Universal High Temperature Cement.

Instrument Investment News

Published by Consolidated Ashcroft Hancock Co., 100 E. 42 St., New York, N. Y., has articles entitled: "Good to the Last Drop;" Do you have heating complaints; The Speed Limit must not be Exceeded; The Sahara Desert in the Print Shop.

Instruments That Make Flying Safe

The Pioneer Instrument Company, 754 Lexington Ave., Brooklyn, N. Y., have issued this booklet tracing the History and Growth of their company.

Levels and Theodolites

Gebr. Wichmann, Berlin W6, Germany, have issued a bulletin on levels and theodolites.

Meeting Your Ideas on the Flow Problem

Points out the features of the flow meter manufactured by the Brown Instrument Company, 4482 Wayne St., Philadelphia, Pa.

Moisture Meter

Bulletin No. 975 issued by C. J. Tagliabue Mfg. Co., 18 Thirty-third Street, Brooklyn, N. Y., describes the Tag-Heppenstall Moisture Meter for determining the moisture content of wood.

Mercoids

The January issue of Mercoids, published by The Mercoids Corporation, 564 W. Adams St., Chicago, Ill., describes The Interlock—A New Development in Automatic Controls.

Penescope

Bulletin No. 18 issued by the Thwing Instrument Co., 3339 Lancaster Ave., Philadelphia, Pa., describes the Penescope an instrument for testing the permeability of paper, etc. to water, moistures, oils and solutions of electrolytes.

Power Plant Instrument Data Book

This book published by the Brown Instrument Company, 4482 Wayne St., Philadelphia, Pa., discusses 105 applications of instruments to the steam power plant for measuring temperatures, pressures, flows, liquid levels, % CO_2 and speeds.

Price List

J. T. Baker Chemical Company, Phillipsburg, N. J., have issued a Price List on Chemicals dated Feb. 1, 1929.

Regulation of Respiration

is the title of a reprint from the American Journal of Physiology, being distributed by Leeds & Northrup Company, 4901 Stenton Ave., Philadelphia, Pa. It describes a quinhydrone electrode for CH determinations on small samples without loss of carbon

Recording Microphotometer
P. J. Kipp & Zonen, Delft, Holland, have issued a leaflet on their Moll Recording Microphotometer.
dioxide.

Stability Indicator and Recorder
Dobbie McInnes & Clyde, Ltd., 57 Bothwell St., Glasgow, Scotland, have issued a bulletin describing the "Stabilograph" for obtaining accurate records of ships' stability, metacentric height, natural period of roll, acceleration of speed, launching declivity and acceleration down the slipway, initial and sliding slipway frictions.

Smelting Ore More Uniformly
Circ. F-9-P25, 127 of the Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa., shows charts obtained with the L. & N. Hot Blast Recording Controller and Top Temperature Recorder.

The Moving Pointer
The Foxboro Company, Foxboro, Mass., have issued a leaflet on their draft gauges. This is leaflet DMF 548.

Temperature Color Chart
The Brown Instrument Co., 4482 Wayne St., Philadelphia, Pa., have available a blotter showing the difficulty of gauging temperature by eye.

Tachometer
Special Leaflet No. 507 issued by Herman H. Sticht & Co., 21 Park Row, New York, N. Y., covers the Universal Model Standco Hand Tachometer.

Use of Esterline-Angus Instruments in Office, Mercantile and Public Buildings
is the title of Bulletin 229 published by Esterline-Angus Company, Indianapolis, Ind.

Portable Electrical Instruments
Bulletin No. 2012 describing a complete line of intermediate size portable instruments housed in rugged bakelite cases, has been published by the Jewell Electrical Instrument Co., 1640 Walnut St., Chicago, Ill.

Testing Machines
Bulletin E of the Tinius Olsen Testing Machine Company, 500 North 12 St., Philadelphia, Pa., shows various types of ductility testing machines, extensometers and dynamometers.

Gas Analysis
Charles Engelhard, Inc., 90 Chestnut St., Newark, N. J., have issued a bulletin describing the thermal conductivity method of gas analysis and apparatus for CO_2 and SO_2 analysis.

Fuse & Circuit Tester
A leaflet issued by the Electric Tester Mfg. Co., 346 Sherlock Bldg., Portland, Ore., illustrates a fuse and circuit-tester for a.c. or d.c. circuits from 110 to 600 volts.

Voltage Tester
A leaflet issued by the Electric Tester Mfg. Co., 346 Sherlock Bldg., Portland, Ore., covers the Johnson voltage tester manufactured by them.

Watthour Meters
A bulletin illustrating and describing the last minute improvements to the watthour meter has been published by the Duncan Electric Manufacturing Co.

Portable Test Meter
Literature describing a new temperature compensated portable test meter with 6 current ranges and two voltage ranges without multiplier has been issued by the Sangamo Electric Co., Springfield, Ill.

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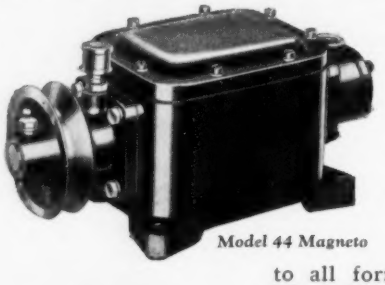

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Current Literature Review

Abstracts on instruments and devices for measurement, inspection and control

The Technology Department, Carnegie Library, Pittsburgh, Pa., will furnish photostats of material abstracted here. Negative prints are 35 cents per page, plus 10 cents for mailing (first class). All orders should be paid in advance. The library is not responsible for loss in mails.

Some Properties of a Fused Silica Tuning-Fork. E. Harrington. Jl. Opt. Soc., Feb. 1929, pp. 89-95.

The logarithmic decrement, the coefficient of damping, and the coefficient of stiffness of a fused silica tuning-fork were determined from data obtained from photographic records of the vibrations of the tuning-fork after it had been struck with a pianoforte hammer.

The Influence of Shaking on Different Precipitation Reactions. G. Thanheiser and P. Dickens. Archiv Eisenhuettenwesen, March 1929, pp. 575-581.

This article considers the influence of shaking on the precipitation in the determination of barium, sulphur, calcium, magnesium and phosphorus.

Lenses and Equipment for Ultra-Violet Photography. J. Gifford. Trans. Opt. Soc., Vol. XXX, No. 1, 1928-29, pp. 34-40.

A description is given of the type of photographic doublet generally known as rapid rectilinear, in which (1) fluorite and quartz, (2) quartz and calcite are substituted for the ordinary crown and flint glasses. These doublets are therefore more or less transparent to the ultra-violet as well as to the visual spectrum. Corresponding lists of focal lengths for twenty-one wave-lengths are given, as well as the radii, thicknesses, etc., for construction. A cement transparent to the ultra-violet for use with these lenses is described, and photographs of the spectra transmitted by certain light filters are given.

The Relations Between Field Illumination and the Optimum Visual Field for Observational Instruments. L. Martin and T. Richards. Trans. Opt. Soc., Vol. XXX, No. 1, 1928-29, pp. 22-33.

The paper describes some experiments based on the application of the results of recent studies on "spatial induction" in vision to determine the conditions governing the optimum size of visual field under certain conditions. The results have a bearing on recent efforts greatly to enlarge the fields of view of binoculars, indicating that small fields are better under certain conditions.

Testing Method for Roofing Felt. P. Codwise. Paper Tr. Jl., Feb. 28, 1929, pp. 43-45.

This paper reports the results of tests made on five different types of felt.—M.B.R.

Proposed Method for Quantitative Determination of Pitch in Wood Pulp. R. Griffin. Paper Tr. Jl., Feb. 28, 1929, pp. 45.

Method briefly outlined.—M.B.R.

A Semi-Automatic Sheet Machine for Pulp Strength Testing. H. Schwalbe. Paper Trade Journal, Jan. 31, 1929, pp. 63-65.

Translation of a paper in the Papier Fabricant, Aug. 5, 1928. An improved type of machine is described.

Temperature Control Apparatus. L. Richards. Jl. Opt. Soc., Feb. 1929, pp. 131-137.

This paper describes an apparatus which may be easily constructed and which may be used to control the temperature of either an air or water bath.—M.B.R.

A Recording Photoelectric Color Analyzer. A. C. Hardy. Jl. Opt. Soc., Feb. 1929, pp. 96-117.

This paper describes in considerable detail an instrument designed for the rapid measurement of color of reflecting surfaces.

The following parts are considered: Optical System, Photoelectric Cell, First Stage of Amplification, Amplifier, Method of Recording, Precision, Integrating Attachment.—M.B.R.

Tests for Paper Quality. R. C. Griffen. The Purchasing Agent, March 1929, pp. 275-278.

This paper discusses the microscopical, physical, chemical and special tests to identify the quality and suitability of paper.—M.B.R.

Equipment for Measuring Lightning Voltages. Ed. Beck. Inst. World, March 1929, pp. 325-326, 340.

Abstract of a paper in Scientific Monthly. Apparatus by which studies were made of lightning transients on actual power transmission lines is described.—M.B.R.

The Baker Automatic Release for Dropping the Meteorograph from a Registering Balloon at a Pre-Determined Height. L. Dines. Inst. World, March 1929, pp. 337-338.

Paper read before the Royal Meteorological Society. The apparatus is briefly described.—M.B.R.

Some Interesting Applications of a Rotoscope. Inst. World, March 1929, pp. 341-343.

A number of unusual applications are discussed.—M.B.R.

Review of Recent Patents

Printed copies of Patents may be obtained as follows:
AMERICAN—Send request to Commissioner of Patents, Washington, D. C., enclosing 10 cents for each patent.
ENGLISH—Send request to His Majesty's Stationery Office Press, Pocock St., S.E.1, London, England, enclosing 1 shilling for each patent.
GERMAN—Send request to Reichspatentamt, Berlin, Germany, enclosing 1 reichsmark for each patent.

United States Patents

LIQUID-DEPTH-INDICATOR-DEVICE. Horace W. King, Berkeley, Calif., assignor to King-Seeley Corp. Pat. No. 1,696,915.

MAGNETIC PYROMETER. Thomas Spooner, Edgewood, Pa., assignor to Westinghouse Elec. & Mfg. Co. Pat. No. 1,697,148.

MAXIMUM DEMAND METER. David C. Davis, Chester, Pa., assignor to Westinghouse Elec. & Mfg. Co. Pat. No. 1,697,166.

CREST VOLTMETER. Charles Le G. Fortesque, Pittsburgh, Pa., assignor to Westinghouse Elec. & Mfg. Co. Pat. No. 1,697,177.

OSCILLOGRAPH GALVANOMETER. Joseph W. Legg, Wilkinsburg, Pa., assignor to Westinghouse Elec. & Mfg. Co. Pat. No. 1,697,191.

FREQUENCY METER. Bernard E. Lenehan, Wilkinsburg, Pa., assignor to Westinghouse Elec. & Mfg. Co. Pat. No. 1,697,192.

WAVE METER. Paul MacGahan, Pittsburgh, Pa., assignor to Westinghouse Elec. & Mfg. Co. Pat. No. 1,697,196.

MEASUREMENT AND REGULATION OF FLOW OF STEAM OR OTHER LIQUID. Grant Campbell, Short Hills, N. J., assignor to Campbell Engineering Co. Pat. No. 1,697,344.

ELECTRICAL MEASURING APPARATUS. Chas. Hilaire, Henri Rodaust, Versailles, France, assignors to Societe Anonynie Establissements Ed Jaeger. Pat. No. 1,697,369.

SPEEDOMETER. Cyril T. Wallis, Rochester, N. Y., assignor to North East Electric Co. Pat. No. 1,697,580.

TEMPERATURE CONTROL APPARATUS. John A. Spencer, Revere, Mass., assignor to Spencer Thermostat Co. Pat. No. 1,697,886.

FLOW METER. Harold H. Mapelsden, Schenectady, N. Y., assignor by mesne assignments to Bailey Meter Co. Pat. No. 1,698,314.

LIQUID-LEVEL GAUGE. Francis B. Smithe, New York, N. Y., assignor by mesne assignment to F. L. Smith Machine Co. Pat. No. 1,698,701.

GAS-ANALYSIS APPARATUS. Richard H. Krueger, Newark, N. J., assignor to Charles Engelhard, Inc. Pat. No. 1,698,887.

AUTO OIL-MEASURING DEVICE. Andrew J. Marshall, Harrisburg, Ill., assignor of one-half to George W. Mitchell, Harrisburg, Ill. Pat. No. 1,698,889.

LIQUID-LEVEL INDICATOR. Jack D. Sartakoff, New York, N. Y. Pat. No. 1,698,969.

LIQUID-LEVEL INDICATOR, Frederic McNeill, Forest Park, Ill., assignor to Boiler Room Improvement Co. Pat. No. 1,699,075.

FLOW METER AND THE LIKE. Louis W. Thompson, Schenectady, N. Y., assignor by mesne assignment to Bailey Meter Company. Pat. No. 1,699,126.

GAS METER. Arno R. Huettig, Stratford, Conn., assignor to American Meter Company, Inc. Pat. No. 1,699,145.

DEPTHOMETER. Wilfred H. Geis and Jay Emery Van Gundy, Los Angeles, Calif. Pat. No., 1,699,235.

TEMPERATURE-REGULATING APPARATUS. Thomas M. Knowland and Howard A. Hands, Watertown, Mass., assignors to Hood Rubber Co. Pat. No. 1,699,296.

THERMOSTATIC CIRCUIT CONTROLLER. Corel A. Stillwell, Ionia, Mich. Pat. No. 1,699,317.

THERMOSTAT. John H. Grayson, Southgate, Calif. Pat. No. 1,699,468.

MEASURING MACHINE. Oscar C. Schmidt, Cincinnati, Ohio, assignor to The Cincinnati Butchers' Supply Co. Pat. No. 1,699,494.

TESTING APPARATUS FOR MEASURING THE COMPRESSIBILITY OF BODIES SOFTENING WHEN COMPRESSED. Hans Hirsch and Hans Hecht, Berlin, Germany. Pat. No. 1,699,589.

TESTING DEVICE. Nils A. Wahlberg, Wilkinsburg, Pa., assignor to Westinghouse Elec. & Mfg. Co. Pat. No. 1,699,771.

ELECTRICAL MEASURING INSTRUMENT. Albert Callsen, Nuremberg, Germany, assignor to Westinghouse Electric & Mfg. Co. Pat. No. 1,699,777.

PRESSURE-DISTRIBUTING DEVICE. Thaddeus R. Goldsborough, Wilkinsburg, Pa., assignor to Westinghouse Elec. & Mfg. Co. Pat. No. 1,699,786.

ELECTRICAL MEASURING INSTRUMENT. Emil H. Greibach, Pittsburgh, Pa., assignor to Westinghouse Electric & Mfg. Co. Pat. No. 1,699,788.

CONTROL APPARATUS. Harold C. Jenks, Wilkinsburg, Pa., assignor to Westinghouse Elec. & Mfg. Co. Pat. No. 1,699,790.

ELECTRICAL MEASURING INSTRUMENT. Raymond T. Pierce, Millburn, N. J., assignor to Westinghouse Elec. & Mfg. Co. Pat. No. 1,699,807.

REVERSIBLE FLOW METER. Frederick N. Connet, Providence, R. I., assignor to Builders Iron Foundry. Pat. No. 1,700,027.

METALLIC THERMOSTAT. Lawrence K. Marshall, Cambridge, Mass., assignor to Spencer Thermostat Company. Pat. No. 1,700,173.

On Multiple Reflection Within a Symmetrical Optical Instrument. T. Smith. Jl. Opt. Soc., Feb. 1929, pp. 75-81.

The Gaussian constants of a symmetrical optical instrument are built up from those of its parts by matrix multiplication. The matrix method is employed to find the constants for light which has been reflected any number of times between two given surfaces of the instrument. The matrix is expressable as the sum of the two parts, each consisting of the product of a trigonometrical function depending on the number of reflections and a matrix which is independent of this number.

Planimeter. K. Trott. Zs. Feinmechanik, Feb. 15, 1929, pp. 4-6.

The article describes the planimeter giving briefly the theoretical considerations.

Practical Consideration for Gas Analysis. (Praktische Richtlinien fuer gasanalytische Untersuchungen.) G. Neumann and F. Straehuber. Archiv Eisenhuettenwesen, March 1929, pp. 557-574.

The article considers the set-up, sources of error and operation of Orsats. It also considers apparatus for precision gas analysis, automatic gas analysis apparatus, devices for gas sampling and evaluation of the results.

Discharge Coefficient of Square-Edged Orifices for Measuring the Flow of Air. H. Bean, E. Buckingham and P. Murphy. B. of S. Jl. Res., March 1929, pp. 561-658.

1. Air at pressures between 1 and 43 atmospheres was passed through square-edged concentric orifices in long, straight pipes of 4, 6 and 8 inches nominal diameter, the three pipes being in series. At each orifice the temperature and static pressure were observed, and the fall of pressure through the orifice was measured between pairs of taps located in each of the three ways commonly adopted in commercial orifice meter practice.

2. The rate of flow was measured by throttling the air nearly to atmospheric pressure and discharging it through a flow nozzle on the end of the line. The design, calibration, and peculiarities of behavior of the nozzles are described, and the theory of this method of measurement is discussed in two appendixes. Such nozzles appear to be very satisfactory for use as primary standards.

3. The various quantities known as discharge coefficients and used in orifice meter computations are defined.

4. The experimental results are represented by equations connecting the values of the discharge coefficients with the ratio of orifice to pipe diameter and with the ratio of downstream to upstream static pressure. Tables of numerical values of discharge coefficients are also given.

5. The accuracy of the results and the limitations to their general applicability are discussed.

Heat Treatment and Testing of High Speed Steel Tools. (Waermebehandlung und Pruefung von Schnellarbeitstahl-Werkzeugen.) F. Rapatz. Stahl u. Eisen, Feb. 21, 1929, pp. 250-255.

The article discusses the possibility of testing high-speed steel tools.

Transmission of Sound Through Wall and Floor Structures. V. Chrisler and W. Snyder. B. of S. Jl. Res., March 1929, pp. 541-559.

This paper contains a report of the work on sound transmission through (1) a large number of masonry walls and floors and other materials which are homogeneous in construction, the results showing that weight is the most important factor under these conditions; (2) a few compound walls and floors which have a masonry core, and (3) a few stud walls.

The results are given for five frequency bands covering a range from 250 to 3,365 cycles per second. Transmission tests were also made for impact noises. Specifications for the construction of the various panels used are appended.

The Calibration of Pendulum Impact Machines (Das Eichen von Pendelschlagwerken.) Max Rudeloff. Messtechnik, Feb. 22, 1929, pp. 31-38.

The Rudeloff machine for tests on freely resting specimens and for specimens held at the ends is described. The results of both methods of testing are given.

Precision Bridges for Direct and Alternating Current. (Praezisionsmessbruecken fuer Gleich-und Wechselstrom.) O. Zwierina, Messtechnik, Feb. 22, 1929, pp. 38-44.

The article discusses the use of direct current bridges for alternating current measurements of audio-frequency.

Oscillation of Pressure in Pipe Lines During Time Closure. E. Parry. Paper No. 4715, Institution of Civil Engineers.

A graphic and an alternative tabular method of computing the impulse due to closure are described which are claimed to be less laborious than other methods in vogue at the present time. The tabular method is employed for obtaining the characteristic impulse pertaining to the five different modes mentioned. The impulse produced by constant retardation obtained by this method is found to agree in all respects with that obtained by the analytical method. An example of the tabular method as applied to the case of harmonically-varying retardation is given.

Method of Testing Clay, Talc and Agalite. D. D. Vong. Paper Tr. Jl., March 14, 1929, pp. 55-57.

Paper presented at the Annual Meeting of the Technical Association of Pulp and Paper Industry. Method is outlined.

Some Aspects of Freeness Testing. D. S. Davis. Paper Tr. Jl., March 14, 1929, pp. 60-63.

Paper presented at the Annual Meeting of the Technical Association of Pulp and Paper Industry. Paper assembles under one heading some of the data collected by the laboratory of the International Paper Company on this field.

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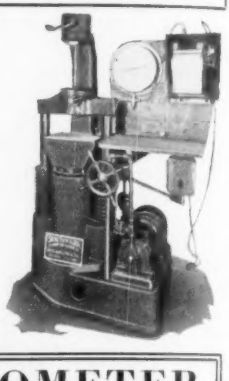

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Stopping Corrosion by Hydrogen Ion Control. F. McCrumb. Power, Dec. 25, 1928, pp. 1038-1040.

Hydrogen ion values are discussed and the La Motte Chemical Company Comparator is described.

Report on Permeability of Paper to Liquids. Allen Abrams. Paper Tr. Jl., Feb. 28, 1929, pp. 40-42.

This is a report of the committee of the Technical Association of the Pulp and Paper Industry. The points discussed are: Method of measuring degree of sizing; Method of Testing grease proofness.—M.B.R.

Fastness to Light of Colored Paper. W. Appel and T. Bentzen. Paper Tr. Jl., Feb. 28, 1929, pp. 42.

This paper briefly reports on questions before the Committee on Fine and Special Papers.—M.B.R.

Quantitative Analysis of the Sun. H. Russel. Sci. American, April 1929, pp. 316-317.

This article discusses the quantitative analysis of the chemical elements on the sun identified by the spectroscope.—M.B.R.

Torsional Vibrations Break Crankshafts. E. C. Magdeburger. Power, Feb. 26, 1929, pp. 371-373.

This article considers the torsional vibrations in crankshafts. The Geiger instrument for measuring torsional vibrations is described.

Automatic Heat Balance Regulation. J. Hoerath. Power, Dec. 11, 1928, pp. 956-957.

The construction of a regulator for automatic heat balance is described.

The Assay of Coal for Carbonization Purposes. Technical Paper No. 21, Department of Scientific and Industrial Research.

This paper is a continuation of Fuel Research Technical Paper No. 1, which described an "assay" apparatus designed to assist in the laboratory examination of coals as to their suitability for carbonisation. The apparatus has been placed on the market and is known as the "Gray-King Assay Apparatus." It has been used for a number of investigations at the Fuel Research Station and elsewhere.

The present paper gives the results of over seven years' use of the apparatus, together with details of the considerations and experiments which led to the original design. The report deals specially with the assay of highly swelling coals, and with the interpretation of the results obtained. A rather larger scale apparatus is also described.—M.B.R.

Transmission Testing of Central Office Circuits. H. Douglas. Bell Labs. Rec., March 1929, pp. 283-286.

Several measuring sets are briefly described and illustrated.—M.B.R.

Notes on Practical Pyrometry. G. Brook and H. Simcox. Inst. World, March 1929, pp. 329-333.

Paper read before the Institute of Metals. Problems of pyrometry are discussed, together with suggested means for surmounting them. A special instrument is described.—M.B.R.

The Schweydar Two-Component Seismograph. Inst. World, March 1929, pp. 335-336.

Description of this instrument manufactured by the Askania Werke.

How Photography Aids the Astronomer in Determining the Rate of Motion of the Stars. C. B. Neblette. Photo-Era, Dec. 1928, pp. 332.

The fact that the lines of the spectrum of a luminous body are shifted when that body is advancing or receding is made use of photographically in determining star velocities. A simple exposition of the method and equipment is given.—Abs. Bull. Kodak Res. Labs.

Continuous Tachymetry from an Automobile for Military Reconnoitre, Route Marking, Explorations, and General Investigations. F. Haeusler. Kinotechnik, Aug. 5, 1928, pp. 409-413 and Aug. 20, 1928, pp. 432-434.

Description of an application of cinematography to rapid general geographical surveys. A one-meter base range finder is fitted to a motion picture machine; the two sighting images are not brought to coincidence as in usual practice but their displacement at any given time is simultaneously photographed and subsequently measured. These records can be made very rapidly by rotation on an axis through 360°. One of the end mirrors of the base line is rotatable in a vertical plane. This mirror is provided also with a reflecting prism which moves with it and throws an image of an index and its adjacent portion of divided circle on the film at the same time as the landscape. By these means declination measurements are photographically recorded of all objects photographed and by similar means the right and left deflections of objects are also photographically recorded on the film from the deflection circle. The apparatus is provided with the usual theodolite levels and in addition the equipment includes a barometer and compass. The whole outfit can be fitted to an automobile and thus be conveyed rapidly over a large area and many records taken with only geographical positions, altitudes, and compass bearings to be personally recorded.

Deals with the methods of measuring the parallax photographically recorded by the continuous range finder machine previously described. Measurement is by projection, and means are also provided whereby the two horizontal cinematograph pictures (i.e., the one obtained from the left end of the base and the one obtained from the right) are brought optically into correct horizontal alignment for visual observation. The two pictures are projected simultaneously with a parallax-distance-scale which provides the means of translating parallax into distance values. It is suggested that projection methods overcome the errors introduced by film distortion.—Abs. Bull. Kodak Res. Labs.

Instruments Book Shelf

Orders for copies of the books reviewed in this section can be sent to Instruments Book Shelf, care of Instruments Publishing Company, 1117 Wolfendale Street, Pittsburgh, Pa.

VIBRATION PROBLEMS IN ENGINEERING. *S. Timoshenko.* D. Van Nostrand Co., New York, N. Y., 1928. Cloth 6x9, 351 pages, 165 figs. Price $4.50 postpaid.

REVIEWED BY RICHARD RIMBACH

Timoshenko develops fully the theory of vibrations, giving the fundamental equations for broad classes of problems. These he illustrates by various examples, in many cases, taken from actual experience with vibration of machines in service. The subject matter is based upon a series of lectures on vibration, which he delivered before the engineers of the Westinghouse Electric & Manufacturing Company in 1925.

The appendix giving a general description of vibration measuring instruments will be the most interesting to INSTRUMENT'S readers, although the chapters, dealing with turbine blade, disk and shaft vibration sum up these problems in a comprehensive manner.

FINDING AND STOPPING WASTE IN MODERN BOILER ROOMS. *Geo. H. Gibson.* Cochrane Corporation, Philadelphia, Pa., 1928. Flexible cloth 5x7, 804 pages. Price $3.00 postpaid.

REVIEWED BY D. L. MATHIAS

This is a reference book of text, tables and charts compiled from papers read before engineering societies, books, articles in technical periodicals, publications of the U. S. Bureau of Mines, and other original sources, and put into convenient form for owners, managers, engineers, firemen and others interested in increasing and maintaining boiler plant economy. The five sections are on the subject of fuels, combustion, heat absorption, boiler efficiency and testing, and feed water heating and conditioning. The aim has been to present data and methods by means of which a reasonably intelligent man can choose and evaluate fuels, select the type of equipment best adapted for burning them, operate such equipment at the highest efficiency and secure efficient transfer of the heat thus developed to the steam. The final section discusses recent practice in heat balancing, water conditioning and protection of the boiler and auxiliary equipment from scaling, embrittlement and corrosion. The work of a great number of investigators is critically digested and concisely presented in convenient form for ready reference.

IMPURITIES IN METALS. *Colin J. Smithells.* John Wiley & Sons, Inc., New York, 1928. Cloth, 157 pages. Price $5.00 postpaid.

REVIEWED BY RICHARD RIMBACH

This book is of practical value to users and manufacturers as well as advanced students of metallurgy.

The following important chapters are included in the contents: Methods of Studying the Structure of Metals;; X-rays and the Structure of Metals; The Structure of Pure Metals; The Structure of Alloys; The Influence of Minor Constituents on Structure; The Influence of Minor Constituents on the Mechanical Properties of Metals; The Influence of Minor Constituents on the Electrical Properties of Metals; The Influence of Minor Constituents on the Corrosion of Metals.

Ample illustrations, tables and charts serve to make clear the text. The reviewer calls attention to a correction in line 13, page 54; the sense seems to require "liquid" instead of "solid."

AMERICAN ANNUAL PHOTOGRAPHY 1929. *Frank R. Frapie.* American Photographic Pub. Co., Boston, Mass., 1928. Paper 7¼x9¾, 240 pages. Price $1.00 postpaid.

REVIEWED BY M. BERG RIMBACH

The 43rd volume of this book is similar to previous volumes. The illustrations have been increased in number and include a larger selection of foreign work than last year as well as 16 pages devoted to the work of American professional and commercial photographers. The number of articles has been increased and an endeavor made to suit the tastes of all classes of readers. The list of camera clubs has been widened to cover the professional associations and groups.

Measurement of Local Iron Losses. (Messung der lokalen Eisenverluste.) L. and P. Lombardi. Arch. Elekt., Feb. 15, 1929, pp. 449-457.

A method for the measurement of local iron losses is described.

The Variation in Engine Power with Altitude Determined from Measurements in Flight with a Hub Dynamometer. W. D. Gove. N.A.C.A. Tech. Report No. 295, 1928.

The hub dynamometer is described in detail in N.A.C.A. Tech. Report No. 252, 1927.—W.G.B.

Report on the Development of a Hot-Wire Descent Meter. Geo. Gardner and F. W. Meredith. Aero Research Com. R. & M., No. 1144, 1928.

An instrument is described which is suitable for use in flight research work.—W.G.B.

Theory of Pressure Capsules. Part I. General Discussion. Part II. The Complete Flat Disk Without Control Spring. A. A. Griffith. Aero Research Com., R. & M. No. 1136, 1927.

A discussion of the general principles underlying the action of pressure capsules.—W.G.B.

Measurement of Pulsating Currents. W. N. Goodwin, Jr. Trans. Soc. Mot. Pict. Eng., 1928, pp. 364-378.

The characteristics of alternating, direct, and pulsating currents are described and graphically illustrated. The various types of measuring instruments are listed and the characteristics and use of each are noted.—Abs. Bull. Kodak Res. Labs.

On a New Machine for Measuring Displacements on Stellar Spectrograms. M. Hamy. Astrophysical Jl., Dec. 1928, pp. 403-407.

This new machine, applying Hartmann's method of comparing a stellar spectrogram with one of the sun, is so arranged that the very narrow stellar spectrum can be measured and need not be widened during exposure. When only one side of the machine is used, the ordinary method of reduction can be followed.

Recording of Data from Measuring Instruments with the Motion Picture Camera. L. Fink. Kinotechnik, Nov. 20, 1928, pp. 580-586.

General instructions are given for using a motion picture camera for recording data from various types of measuring instruments. Arrangement of the instruments, manipulation of the camera, development of the film, and related matters are discussed.—Abs. Bull. Kodak Res. Labs.

New Photographic Recording Oscillograph to be Used in Studying Lightning. Photo-Era, Nov. 1928, pp. 279.

An oscillograph of the cathode ray type is used but the rays are deflected to one side by a magnetic field set up within the instrument by the discharge. A waving line is produced on the photographic film. A flash of one ten millionth sec. duration is capable of being recorded and the apparatus runs automatically for two hours. Rate of rise of voltage, maximum voltage, duration of flash, and rate of decrease may be calculated from the record. It is hoped the results of the experiment will aid in determining methods of preventing interference from lightning, with power transmission.—Abs. Bull. Kodak Res. Labs.

Systematic Control in the Production of Motion Pictures. R. Nauman. Trans. Soc. Mot. Pict. Eng., 1928, pp. 310-316.

The author discusses the value of reflecting power measurements for the materials used in sets. Such values determined by photo-electric measurement would be helpful in setting the exposure. Quantative methods throughout the whole process of picture production are desirable.—Abs. Bull. Kodak Res. Labs.

Errors in Observation in Surveying. H. C. Mitchell. Military Engineer, March April, 1929, pp. 106-111.

The errors are classified and discussed.

An Interlaboratory Comparison of Colored Photometric Filters. E. Crittenden and A. Taylor. Trans. I.E.S., Feb. 1929, pp. 153-207.

This paper reports results of measurements of seven laboratories using more or less diverse methods, on photometric color filters ranging from dark red to purplish blue. Six laboratories made spectrophotometric measurements from which integral transmissions for light corresponding to a color temperature of 2680°K were calculated by means of the standard values for visibility of radiation. Transmission factors so found were very consistent. Measurements made by flicker and by equality-of-brightness photometers gave average results not systematically different from those calculated from the spectral transmissions, but with both types of photometer there were discrepancies between laboratories. Different types of equality-of-brightness photometers also gave quite different results in measurements made by a single group of observers. The net result of the project is to establish very reliable values for sets of filters to be used in all these laboratories as well as to show the practicability and propriety of using spectrophotometric measurements as a basis for standard values.

European Metering Practice. J. Langdell. El. World, March 16, 1929, p. 544.

Multiple-rate meters largely used on account of diversification of schedules. Absence of standardization of frequency and voltage is an added complication of meter practice. Large use of demand instruments.

Distant-Reading Instrument Panels. Engg. Prog., March 1929, pp. 67-69.

This article describes the light-pointer "Profilux" apparatus of Hartmann & Braun.—A.-G.

Strength Testing Machines for Engineering Materials. W. Deutsch and G. Fiek. Engg. Prog., March 1929, pp. 77-83.

Various types of tensile test machines are described.

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THE MEASUREMENT OF PULSATING CURRENTS.

W. NELSON GOODWIN, JR., INSTRUMENTS, Vol. 2, No. 4, April 1929, pp. 115-122, 7 figs.

The characteristics of alternating, direct, and pulsating currents are described and graphically illustrated. The various types of measuring instruments are listed and the characteristics and use of each are noted.

THE SOLENOID ACCELEROMETER.

R. W. BROWN, INSTRUMENTS, Vol. 2, No. 4, April 1929, pp. 123-124, 3 figs.

A special accelerometer designed to study the riding qualities and the momentary loads imposed upon the road is described and illustrated.

A SUPER-MICROMANOMETER.

JOHN L. HODGSON, INSTRUMENTS, Vol. 2, No. 4, April 1929, pp. 125-128, 4 figs.

This article describes and illustrates a micromonometer which can be read to 1/10,000" by means of a reading microscope. With a working slope of 1 in 10 for the gauge tube the meniscus is easily read to an accuracy corresponding to a change in oil level of 1/100,000".

SOME MAGNETIC PROPERTIES OF MONEL METAL.

DAVID R. INGLIS, INSTRUMENTS, Vol. 2, No. 4, April 1929, pp. 129-132, 3 figs.

Two methods were employed in studying the magnetization-temperature curves in this work—magnetometric and oscillation methods. The results are given.

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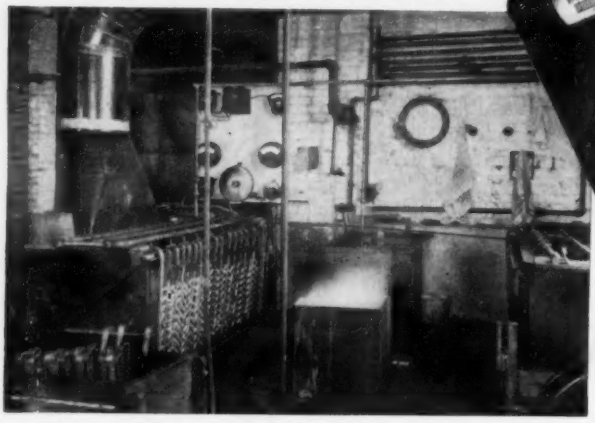

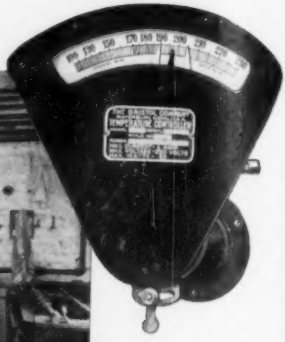

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